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Evaluation method of open spaces for earthquake disaster prevention in urban residential areas in China

Doctoral Dissertation

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EVALUATION METHOD OF OPEN SPACES FOR EARTHQUAKE DISASTER PREVENTION IN URBAN RESIDENTIAL AREAS IN CHINA

Contents

List of Publications

Journal:

1. **Ma,X**, Ohno,R.(2013), Earthquake Resistant Residential Neighborhood in China: Examination of vulnerability in outdoor spaces. *Asian Journal of Environment-Behaviour Studies.* Volume 4, No.11, Jan. / Feb. 2013, pp 1-14.
2. **Ma,X**, Ohno,R.(2013), Development of a method to measure outdoor space using an AutoCAD application. AIJ journal of Technology and design (日本建築学会技術報告集). vol.19 No.43 Oct. 2013, pp1085-1089.
3. P. Villagra, C. Rojas, R. Ohno, **M. Xue,** H. Fuentes (2014), A GIS-based exploration of the relationships between open space systems and urban form for the adaptive capacity of cities after an earthquake: the cases of two Chilean cities. Applied Geology (Accepted)

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2. **Ma,X**, Ohno,R.(2012), A study on open space analysis towards earthquake disaster mitigation in the urban residential environment in china, Taiwan-Japan Symposium on Advancement of Urban Earthquake Hazard Mitigation Technology, National Central University, 17th -20th Sept, 2012, Taiwan.
3. Ma,X, Ohno,R.(2012), The open-space networks in residential environment in China for disaster mitigation. Aips 22 International Association of People-environment Studies Conference, 24th -26th Jul. 2012, University of Strathclyde, Glasgow, Scotland.
4. **Ma,X,** Ohno,R.(2012), A study on open-space network of residential area in China relating to earthquake disaster mitigation, EDRA 43 Environmental Design Research Association conference, 30th May-2nd Jun. 2012, Seattle, US.
5. **Ma,X**, Ohno,R.(2012), A study on disaster Mitigation park system In China--The open space network of residential area, Proceeding of 9th CUEE and 4th ACEE Joint Conference, March 6th -8th 2011 Tokyo Institute of Technology, Japan.
6. Ma,X, Ohno,R.(2011), Examination of vulnerability of various residential areas in China for earthquake disaster mitigation, AicE-Bs 2011 Conference, 6-8 Dec. 2011, Famagusta, Turkey.
7. **Ma,X**, Ohno,R.(2011), Development of a method for detecting vulnerable area by urban texture,, Proceeding of 8th International Conference on Urban Earthquake Engineering, March 6th -8th 2011 Tokyo Institute of Technology, Japan.

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Chapter 1

Introduction

1 Introduction

1.1 Background

China is located in one of the most seismically active regions in the world. Consequently, it has been plagued by countless earthquakes due to its vast territory, complex terrain, and landforms (Office of National Commission for Disaster Reduction 2012). Since the beginning of the 20th century, China has had nearly 800 quakes with a magnitude exceeding six on the Richter scale, and the stricken area covers over 300,000 square kilometers and more than 7 million buildings have been destroyed (China Seismological Bureau n.d.).

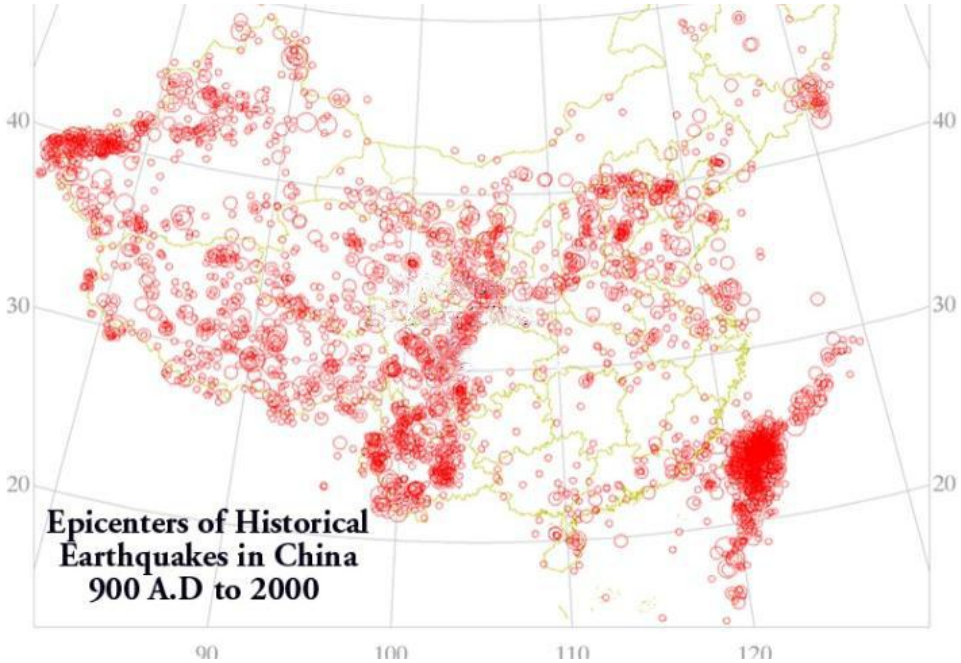


Figure 1-1: Historical map of earthquakes in China
(Resource: http://www.drgeorgepc.com/quake2008ChinaSichuan.jpg)

Since 1950, five massive earthquakes, including the famous Wenchuan earthquake in 2008, have caused immense loss of life and property. Because the current situation in Chinese cities and the disaster prevention system have complicated the prevention and response to natural disasters, improvement of disaster-resistance capabilities has become a primary issue in China. This research is significant because it focuses on disaster prevention through an urban planning approach.

1.1.1 Characteristics of China's earthquake damage

Earthquakes have occurred in almost all provinces, municipalities, and regions, except the Guizhou and Zhejiang provinces. Regardless of the location of an earthquake, the major cause of human injury and death is crushing due to the collapse of vulnerable buildings and houses. The most dominant features of earthquake damage in China are a large number of fatalities and a slow recovery. The former is triggered by the poor building quality and evacuation efficiency, whereas the latter is due to the lack of an emergency and rescue response system as well as slow policy decisions.

In the 2008 Sichuan earthquake, the complex terrain and disruption in communications magnified the damage and resulted in delayed rescue access. Nearly 90,000 people died or were missing, 4,000 houses were destroyed, some towns were flattened, and the infrastructure was severely affected. Direct losses totaling about 1,500 billion USD strained the local economic recovery (China News Service 2008).

Figure 1-1 Collapse due to the structural failure in the 2008 Sichuan earthquake

1.1.2 Current disaster prevention system in China

An earthquake disaster prevention system is one of the most important parts of a national disaster mitigation system. However, it remains insufficient and unenlightened in China. The UNDP report on the 2008 Great Sichuan Earthquake commented that the disaster mitigation and emergency response system in China is incomplete, and noted

deficiencies in the following (UNCRD 2009):

1. Emergency coordination system
2. Law and preparedness system
3. Information sharing system
4. Emergency facilities
5. NGO activities
6. Well-trained rescue teams
7. Storage of emergency goods
8. Community capacity of disaster reduction

China's evacuation system is insufficient against a natural disaster as the present system was designed as war defense shelters in underground spaces. Once an earthquake occurs, there are limited evacuation spaces and few signs indicating evacuation routes to orient citizens and help them evade danger.

After several big earthquakes in recent years, the Chinese government has become determined to develop a disaster mitigation system despite the obstacles. The main goals are protection of people's lives and property, and China has mainstreamed natural disaster risk reduction into its economic and social development plan. To date, a few laws and acts have been instituted to provide the framework for the disaster mitigation system.

In 2006, the National Council issued the ***National Master Plan for Responding to Public Emergencies***, which is an overall framework for use at all levels of government to ensure public security and to cope with public emergency events, including disaster response activities. Activities include: 1) Improving the legislative system for natural disaster risk management; 2) Prioritizing natural disaster risk investigations and zoning; 3) Vigorously strengthening building capacity for natural disaster monitoring and early warning; 4) Steadily implementing disaster prevention and reduction projects; 5) Strengthening studies on natural disaster risk assessment technology; 6) Actively improving natural disaster insurance; 7) Vigorously developing community-based natural disaster risk management; 8) Strengthening international exchanges and cooperation in the field of natural disaster risk management (Office of National Commission for Disaster Reduction 2012)

National planning of comprehensive disaster prevention and mitigation (2011–2015) (General office of the state concil of China 2011) is a five-year plan for a disaster mitigation system in which the requirements and targets of disaster mitigation are specified as guidelines to promote research and social development. Local governments have also made efforts in regional planning to clarify local targets for disaster mitigation, such as: ***Five-year plan of disaster prevention and mitigation for urban and rural***

construction of Beijing and Planning of shelters for earthquake disaster mitigation in the central town of Beijing.

However, some of these efforts are superficial, and their feasibility or availability is doubtful. In the *Planning of shelters for earthquake disaster mitigation in the central town of Beijing*, the shelters are arranged randomly based on several city parks without considering the population capability, population distribution, evacuation accessibility, and shelter functions. Under this plan, the district authority of Beijing city commented on the choice of shelter locations and the fact that signs for Emergency Shelters were placed without indicating safe evacuation routes.

Figure 1-3 Planned disaster mitigation parks in Beijing

(Resource: Beijing Municipal commission of urban planning)

Figure 1-4: Signs denoting evacuation sites in the parks of Beijing city

1.1.3 Necessity of the present research

In accordance with the characteristic of earthquake damage in China and the physical characteristics of China's cities, improving the disaster-resistance capability is an urgent target. To create a realistic and solid disaster prevention system, the weaknesses of the current disaster prevention system must be addressed from the viewpoints of technical issues, policy, management, and urban planning.

Using a planning approach, this research focuses on open spaces in residential environments to develop a method to examine vulnerabilities in residential areas and to determine the relationships between open spaces and a disaster prevention system. These factors must be understood to realize the actual requirements of different urban areas in a complex urban residential system and to help develop a plan that more effectively utilizes open spaces for disaster prevention.

1.2 Vulnerability of cities towards earthquake disaster prevention

Japan is one of the most earthquake-prone countries in the world, experiencing about 10% of the world's tremors. Because Japan has the most advanced disaster prevention system, some of the experiences and mechanisms should be invaluable to develop China's disaster prevention system. For example, a system called the "earthquake vulnerability evaluation system" is a sophisticated method for earthquake disaster prevention in Japan.

1.2.1 Method to evaluate the earthquake vulnerability in Japan

All communities in urban areas were evaluated to assess the most critical vulnerabilities. Then the results were used to promote preparations for earthquakes by enabling the local government and residents to understand the vulnerabilities of their community. Additionally, re-development was based on a community's need for disaster-resilience improvement.

In the case of metropolitan Tokyo, a *survey of district-based vulnerabilities to earthquake disaster —Main vulnerability item in Tokyo—* is conducted and continuous improved in each 5 years, until the 7th survey report was published in 2013.

> *A 70% possibility for a massive earthquake with a magnitude of about 7 may hit Kanto region within the next 30 years. In order to make Tokyo can stand up to disasters, it would be important to not only build a disaster-resilient city by upgrading roads, parks, and other infrastructure, and making buildings fire-resistant, but to also have each and every resident of Tokyo fully prepared for a disaster.* (Bureau of Urban Development of Tokyo 2013).

Figure 1-5 summarizes building collapse risk (danger of building collapse), fire risk (danger of fire spreading), combined risk (danger of building collapse and fire), and risk due to emergency response difficulties (risk in light of the ease/difficulty of conducting emergency response operations such as evacuation and firefighting). The risks and potential causes are ranked on a five-point scale where level 1 (5) indicates a low (high) risk.

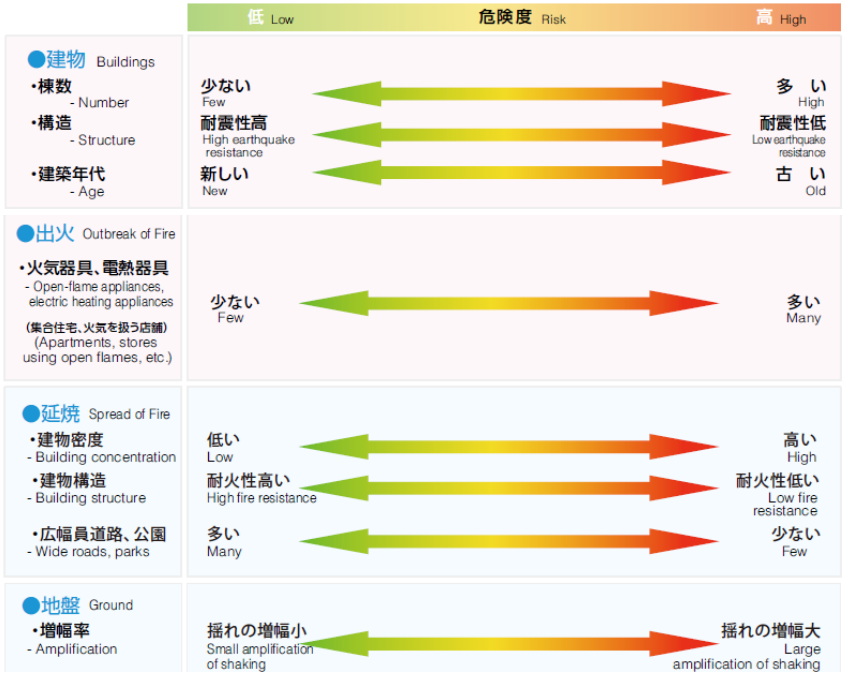


Figure 1-5: Relations between building properties and building collapse risk and fire risk and the risks of fire outbreak/spread

(Resource: The Seventh Community Earthquake Risk Assessment Study 2013)

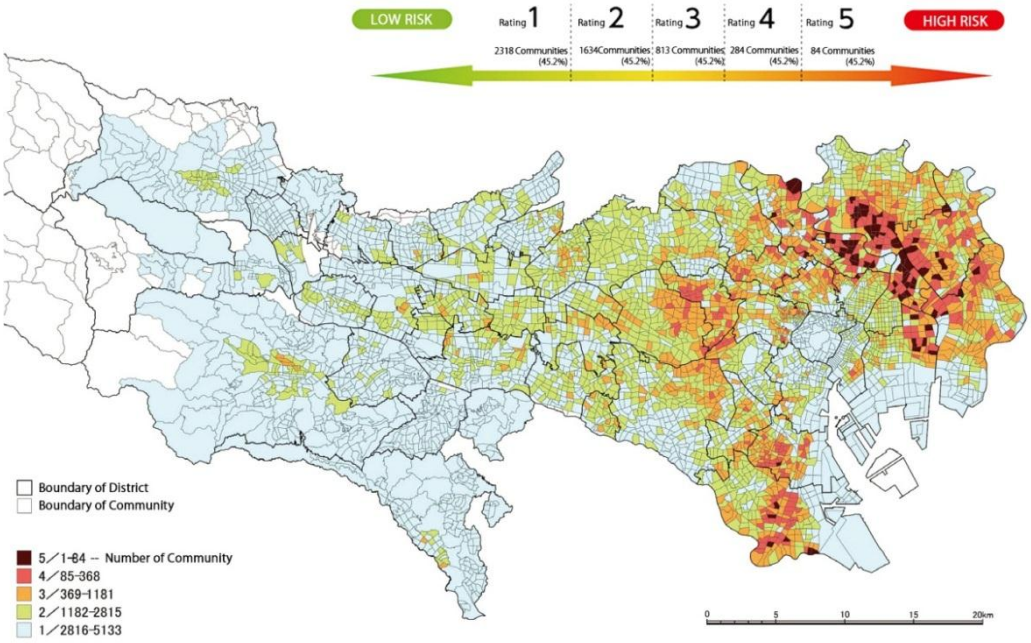


Figure 1-6: Map of the Combined Risk Ratings in Light of Emergency Response Difficulties

(Resource: The Seventh Community Earthquake Risk Assessment Study 2013)

1.2.2 Main vulnerability in Chinese cities

According to the physical and social conditions, different urban situations demand different urban constructions. Because each city faces different dangers when an earthquake occurs, the disaster prevention requirements are diverse. Comparing the urban areas in China and Japan may provide a better understanding of the different characteristics of Chinese cities.

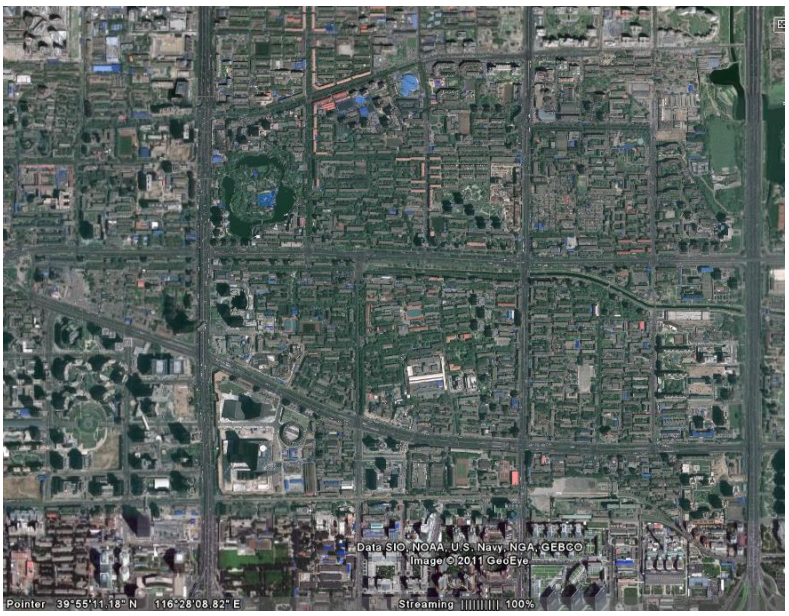


Figure 1-7: In a typical urban texture, superblocks in China are divided by big avenues (Google map)

Figure 1-8: In a typical urban texture in Japan, a continuous pattern consists of dense and narrow streets (Google map)

Residential buildings: Both the structure and form differ. In China, multi-floor dwellings (six or more floors) with a masonry or concrete structure are predominant, while wood-frame detached houses (less than three floors) are more prevalent in Japan. In addition, the building quality in China is inferior, resulting in more collapses and structural damage, but fewer fires when an earthquake occurs.

Road patterns: The Japanese road system is a network of dense but narrow streets, whereas the Chinese system tends to have main roads that are big avenues with widths of 40–80 meters and a 500–800 meter green belt along both sides and the secondary roads are usually wider than 20 meters.

Evacuation system: Evacuation spaces in Japanese cities are systematically and efficiently distributed from neighborhoods to municipalities. In Chinese cities, even the territory of urban area is broad, and the road system may function as evacuations spaces, but an evacuation system was not part of the urban design and construction.

Table 1-1: Characteristics of urban areas in China and Japan

Characteristics	China	Japan
Building structure in vulnerable urban areas	Concrete/brick	Wooden-frame
Building type in vulnerable urban areas	6floors / High-rise(>18)	Low-rise(<10)
City Road pattern	Wide avenue divide urban area into superblock	Continuous pattern consist by dense and narrow street
Evacuation spaces system	Unplanned and inadequate	Systematically
Concerned dangers	**Building collapse** **Falling of Debris**	Spreading of fire Building collapse

Based on these characteristics, the earthquake vulnerabilities in China are more likely to be building collapse, falling debris, and unsafe evacuation.

1.3 Open space as measures for disaster prevention

According to the dominant earthquake vulnerabilities in Chinese cities, both technical measures and policy improvements can help mitigate earthquake damage. For instance, promoting natural disaster risk investigations and zoning may realize a comprehensive assessment of the situation and the benefits of proper preparation. Strengthening the research of earthquake-resistant technology may directly enhance the safety of buildings and reduce the risk of collapse.

Within hours after an earthquake, the primary concern is security and shelter, and establishing shelters and disaster mitigation centers from the regional to the local level could

ensure the supply of post-disaster goods in order to sustain basic life demands. Strengthening the planning of evacuation system is also important because it could ameliorate safety during an evacuation. Thus, creating evacuation routes and the open spaces, which should facilitate evacuation and other disaster prevention functions, plays a very important role in urban areas.

1.3.1 Open space

Open space is defined as any piece of undeveloped land (without buildings or other man-made structures) that is accessible to the public (United states Environmental protection Agency n.d.). Open spaces include green spaces (e.g., parks, community gardens, and cemeteries.), schoolyards, playgrounds, public seating areas, public plazas, and vacant lots.

1.3.2 The open space system for disaster prevention in Japan

The disaster mitigation park system, which is a combination of an evacuation system and urban open space system in Japan, facilitates most of the functions required for evacuation, temporary staying, and goods supplement. The system has five to six different levels according to the size and location of the open spaces. Each level of open space provides a different function in a post-disaster period (Urban Green Resources Development Agency and Commitee of disaster mitigation park technology 2000):

1) Wide regional disaster mitigation centers
2) Regional disaster mitigation centers
3) Wide regional evacuation sites
4) Temporary evacuation sites
5) Neighborhood evacuation sites
6) Evacuation paths/green buffers

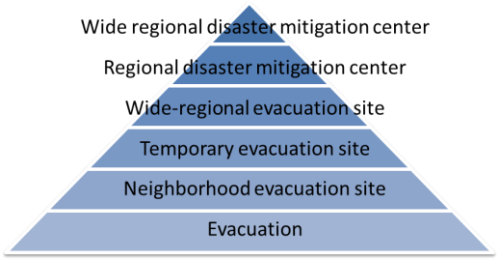


Figure 1-9: Classification of the disaster mitigation system in Japan

Table1-2: Relationship between parks and disaster mitigation sites in Japan [11]

Scale of Parks	Area of Parks	Area of disaster mitigation site	Scale of disaster mitigation site
National Park	A(area)>300(Ha)		Regional Disaster mitigation center
Regional Park	A>50	A>50(Ha) A>10	
Sports park Integrated Park	A=15-75 A=10-50		Regional evacuation site
Community park Neighborhood park	R=1000 A=4 R=500 A=1-2	A>1	Temporary evacuation site
Park in block	R=250 A=0.25	A>0.05	Neighborhood evacuation site

In 1995, the urban area of Kobe was damaged by the Hanshin-Awaji earthquake (7.3 magnitude). Many buildings collapsed and numerous houses burned in subsequent fires, triggering heavy casualties. Public open spaces, which served as barriers to prevent fires from spreading, worked as intended. Additionally, roads acted as buffers and prevented fire from spreading to nearby buildings. Roads wider than six meters were especially effective fire barriers, preventing the spread of almost half of all fires (Yamoto 2006). Consequently, open spaces provided to evacuation sites, disaster relief, life support, a lifeline system, and temporary housing distribution.

Figure 1-10: Equipped automatic water gate and selected trees are expected to prevent fires from spreading in the Igusamori disaster mitigation park, Sikunami district, Tokyo

1.3.3 Classification of open spaces by urban structure

Open spaces in Chinese cities also exist on different scales, which are divided by urban elements and could be used for disaster prevention. We classify urban elements into five categories based on their scale: buildings, neighborhoods, communities, superblocks, and cities.

Neighborhoods: In this research, a neighborhood is generally defined spatially as a specific geographic area of a residential site. Neighborhoods tend to be less than 15 ha.

Superblocks: A superblock is an easily identified area divided by wide avenues, and is between 600–800 m * and consists of one or several neighborhoods.

Communities: A community is predetermined by the administrative division in Chinese cities. Each community has its own community office, which oversees the basic management of the area. A community may contain one or several superblocks, and several communities form an administrative “district”.

Cities: A city is an assembly of administrative districts.

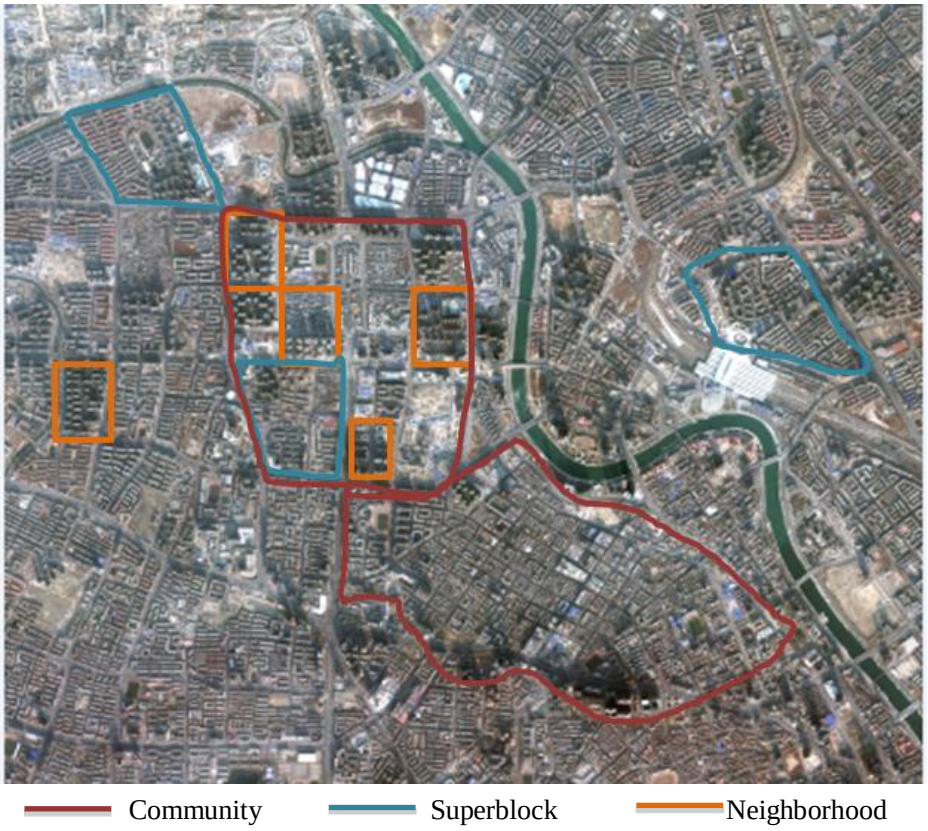


Figure 1-11: Scale of urban elements (Resource: GEO-eye1)

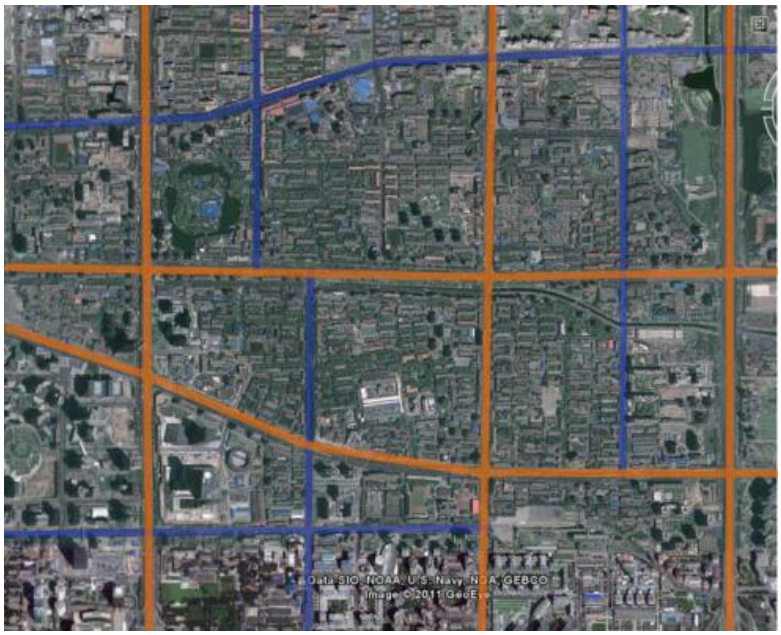


Figure 1-12: Superblocks divided by wide avenues (Google Map)

Under this hierarchy, superblocks are divided and surrounded by wide avenues with typical widths of 15–60 meters. Although these avenues are regarded as safe evacuation routes, they may not be directly accessible due to difficulties within the superblocks (e.g., a

natural barrier or a human-caused barrier). Thus, an essential role of open spaces within a superblock is to act as a direct evacuation route.

1.3.4 Utilization of open spaces for disaster prevention in Chinese cities

After an earthquake, open spaces are common evacuation routes because people use accessible open spaces to evade the dangers of remaining inside a building and to reach safer locations. Additionally, open spaces are used to transport and manage goods.

Figure 1-13: Evacuation and emergency relief in open spaces in the 2008 Sichuan earthquake

Figure 1-14: Residents staying in open spaces after 2008 Sichuan earthquake (Resource: photo by Gael Michaud)

In the aftermath of the 2008 Sichuan earthquake, fear of aftershocks caused a lot of people to stay in the open spaces near their apartments as a safety precaution for several days to one month afterwards (Xuemei 2013). Four million people (14 billion in total) slept in the open spaces (e.g., squares in residential sites, avenues, and neighborhood parks) in the city of Chengdu, which is the capital of the Sichuan province, demonstrating that open spaces are sites for temporary staying in residential areas.

1.3.5 Utilization of open spaces in other countries

There are numerous examples around the world of how open spaces provide various functions for survival and to satisfy the basic life demands in post-disaster periods.

In 1906, the city of San Francisco, California experienced a magnitude 7.7 earthquake, which left many houses uninhabitable, and resulted in a fire that ravished over half of the city in three days (Allan and Bryant n.d.). Wide streets and hill-top parks provided escape routes, refuge, and shelter for a large proportion of the residents remaining in the city. Local parks were an important source of information and community support, and campsites were erected at various military installations, parks, and open spaces throughout the city (Greely n.d.) These camps supported diverse everyday functions (e.g., kitchens, restaurants, etc.). All types of commerce flourished in these open spaces for months and in some cases years after the earthquake. These green spaces greatly contributed to the physical resilience of San Francisco.

Figure1-15: Kitchen in the open space along the street one year after the earthquake
(Resource: California state library, Left
Bancroft library, Right)

In 1960, Valdivia, Chile experienced the largest earthquake of the 20th century (magnitude 9.5). Streets, the river promenade, parks, wetlands, and hills all played a role in earthquake recovery. Dr. Paula's research following this earthquake found that streets followed by plazas and open lands were the most commonly utilized places. Open spaces were mostly used as escape routes and gathering places, and over time, they were used to meet the considerable increase in temporary tent housing, medical care, and storage of supplies. In addition, the earthquake caused extensive areas of the city to flood. Consequently, open spaces on high land were used for the radio station to provide information and community support (Villagra 2010).

Figure1-16: Radio station in a highland in Valdivia, Chile (Resource: Paula Villagra)

In 2010, Concepción, Chile experienced an 8.8 magnitude earthquake, which generated a blackout that affected 93% of the Chilean population and lasted for several days in some locations. People used open spaces, especially near water resources, to maintain basic life demands.

Figure1-17: Utilization of waterfront spaces in the aftermath of the earthquake in Concepción, Chile (Resource: Jose Luis Saavedra, Reuters)

In 2006, the Indonesian island of Java was struck by a 6.3 magnitude earthquake with an epicenter about 20 km from Yogyakarta. The earthquake killed over 5,000 people and displaced 200,000 from their homes [Rachma 2013]. After the earthquake, residents set up campsites, UNICEF created temporary medical centers, and the army erected stations in the open spaces.

Figure1-18: Campsite in open space

Figure1-19: Left, Army station; Right, medical center

1.3.6 Conclusion

Creating a proper open space system is a very effective approach for earthquake disaster prevention because open spaces can host various activities after a disaster occurs. Residents prefer to use open spaces near their houses right after a disaster as evacuation sites and temporary staying. Because open spaces in China inside superblocks are very important to provide evacuation routes and temporary staying, the rest of this paper focuses on open spaces within superblocks.

Urban areas have various uses (e.g., commercial, industrial, residential, etc.), road patterns, and types of buildings. If an earthquake occurs during the night, land in commercial areas may face less risk compared to residential areas. Because the high and variable population mobility makes it difficult to observe and estimate earthquake damage, the present study focuses on the residential areas, which are relatively stable in terms of mobility.

1.4 Previous research

Some researchers have stated that utilization of open spaces for disaster prevention is important and that open spaces can facilitate different functions necessary during and after a disaster (both short- and long-term).

Allan, P., & Bryant, M. (2011) wrote, "Such a system has been characterized as a dormant network of streets, plazas, parks, parking lots and vacant lots, which in times of crisis can be activated to satisfy needs for survival, both from a physical as well as from a social perspective." They also found that after an earthquake, the role of open space changes and the extent such a network contributes to urban resilience depends mostly on the diversity, repetition, and distribution within the city grid. "When built infrastructure and lifeline systems are destroyed, the open space system can provide space to implement an alternative survival

network." [17]

Paula Villagra advocates that caring about the role of open space and people's relationship to the landscape formed by the open space network after an earthquake are important. "Mostly streets, plazas, parks and football fields — which are the result of urban planning and design — as well as rivers and wetlands formed by natural forces are useful for earthquake recovery. Their diversity, utility, and distribution were found to increase over time with positive effects for urban resilience." [Villagra 2010]

Prof. Hayashi, M. thinks that from the experiences of the Great Hanshin-Awaji Earthquake, it is important in the post disaster period that open spaces inside a city are used for shelter and temporary housing. "Emergency experts can find space to provide services and supplies such as food, goods, and medical care". Additionally, this paper reports that open spaces can provide a regional function. "It [open space] not only services local residence but also provides space to other regions." (Hayashi 2010)

Minoda H (1996). His research reported the situation of utilization of the park system in Kobe, where parks were used for disaster mitigation for ten or more months. Evacuation, disaster relief, life support, lifeline system, and temporary housing distribution all utilized the park system. (Minoda 1996)

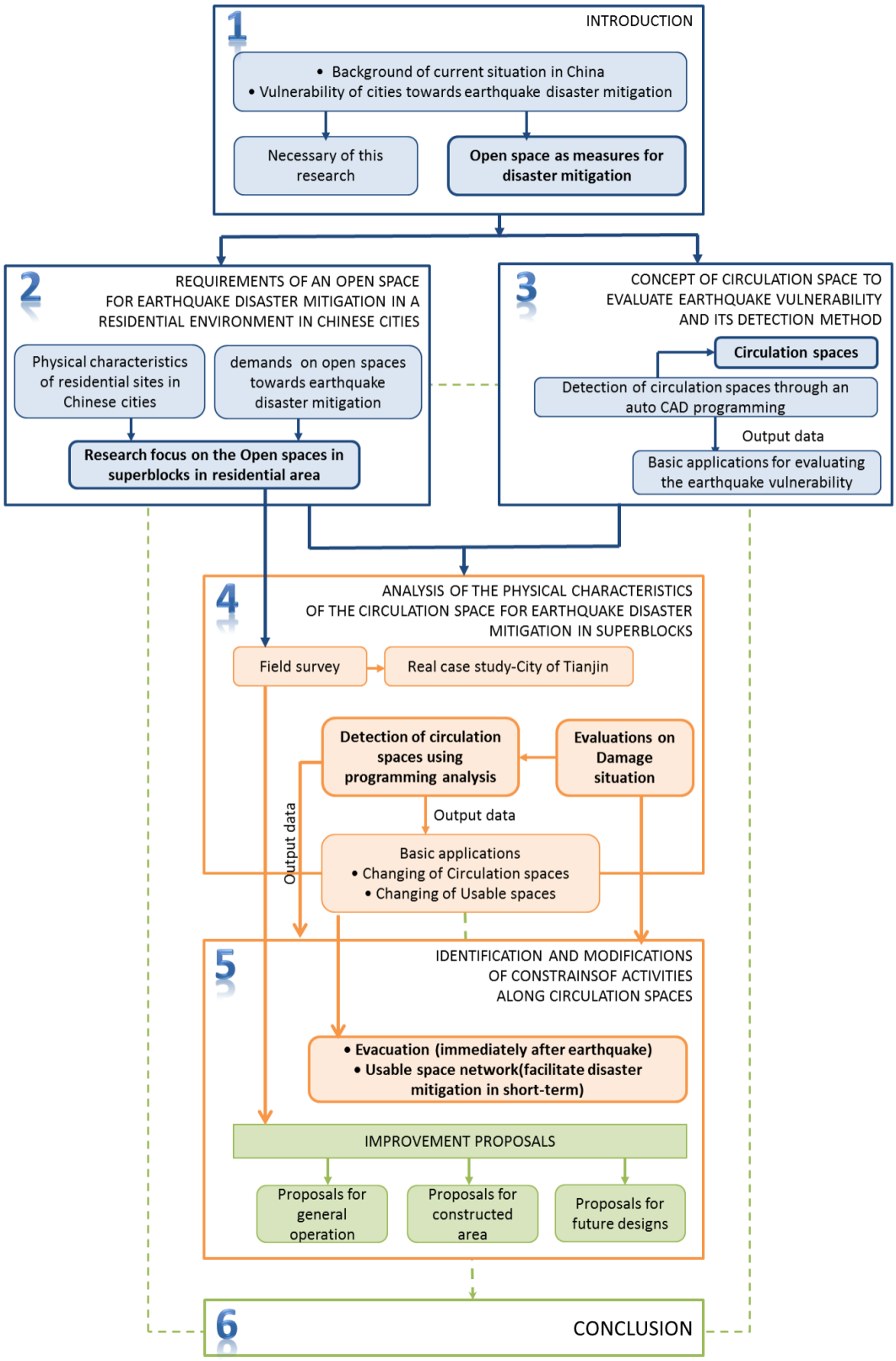
1.5 Objectives

Because understanding why damage and fatalities occur will reduce the casualties from an earthquake, this study examines the vulnerabilities toward earthquakes in residential areas of Chinese cities as a first step. Open spaces are considered to play an important role in earthquake disaster prevention, and their evaluation is significant to assess the safety level in an urban residential environment. Developing a method to measure open spaces should provide a criterion to describe and evaluate vulnerabilities.

In the future, we will analyze the function and performance of open space networks in different scenarios using the above evaluation measure. This should provide an understanding of the current environment as well as create a strategy to more effectively utilize open spaces for disaster prevention.

1.6 Research framework

Table 1-3: Research Flow Chart



Chapter 2

Requirements of an open space for earthquake disaster mitigation in a residential environment in Chinese cities

2 Requirements of an open space for earthquake disaster prevention in residential environments in Chinese cities

2.1 Current vulnerabilities of residential areas related to earthquake disaster prevention in China

As mentioned previously, most Chinese cities are divided into superblocks with wide avenues, which serve as the main roads. In residential areas, the textures inside and in between superblocks usually show similar patterns with regard to building types, building density, road pattern, and even history background. Therefore, the characteristics of residential areas can be observed by categorizing the superblocks. Problems of residential areas related to earthquake vulnerabilities may arise from different aspects (e.g., building structure, area accessibility, management, and environmental issues).

2.2 Physical characteristics of residential area in Chinese cities

The urban fabric of Chinese cities is becoming more intricate, but can be characterized by its highly dense population and construction. In residential areas, the Net Residential Density (number of residents / areas of land for residential) is high. Each residential site is usually not lager than 15ha, according to the Code for planning design of urban residential area in China, 7,000–15,000 people live at each residential site on average, in each living unit (apartment), there has 2.8-3.2 people depending on different cities. (China Architecture & Building Press 2002)

2.2.1 Characteristics of residential buildings

Buildings are the most important component of city. Residential buildings can be classified in various ways. One appropriate standard to categorize buildings in China is the year built, which relates both the earthquake-resistant level and building appearance.

Most residential buildings built between the 1960s and 1980s are one- or two-story brick courtyard houses. This traditional style is widely distributed throughout China; it is predominant in small cities and villages, but also has been preserved in medium and large cities. Building constructed after the 1980s are multi-layer brick or brick concrete structures, which are fragile and susceptible to earthquakes due to the lack of a reliable earthquake-resistance code when constructed. In the 1990s, new earthquake-resistance codes for buildings and planning debuted, which specified the construction standards and earthquake-resistance level. At the same time, high-rise residential buildings were constructed with a higher building quality and capability.

Chinese cities also contain some special types of residential buildings, such as concession buildings constructed before the 1900s, industrial reform buildings, and the recent low-rise detached housing in suburban areas. Table 2-1 summarizes the characteristics of different types of residential buildings.

Table 2-1 Characteristic of residential building in Chinese cities

Type of residential building	Traditional courtyard houses	Middle rise building		High rise building	Specials		
					Concession building	Industrial reform	Detached house
Built year	1960s–1980s	after 1980s	After 1990s	After 1990s	Before 1900s		After 1990s
Structure	brick	brick or concrete	Shear wall	Shear wall	Masonry	rigid-frame	brick or concrete
Height	1–2 floor	5–6 floors		Over 9 floors	1–2 floor	1–2 floor	1–2 floor
Earthquake resistance performance	Without Earthquake-resistance code	Without clear Earthquake-resistance code	Under Earthquake-resistance code		Earthquake-resistance	Under Earthquake-resistance code	
Image							

2.2.2 Characteristics of the residential environment based on field survey results

Residential sites in Chinese cities always have certain boundaries, occupy an area around 7–15 ha (China Architecture & Building Press 2002), and are a combination of residential buildings and open spaces. Most residential sites are enclosed by fences or balusters for security reasons. Another major element is management of the residential environment. Through a field survey conducted in Tianjin in 2010, we found that the characteristics of residential sites are distinct based on the management.

Figure 2-1: A residential site in superblock
(Resource: Left, GEO-eye 1 / Right, http://www.tjtpk.com/)

To observe real situations of residential sites, the March 2011 field survey was conducted in Tianjin, which is a municipality in northern-eastern China located 120 km away from the Capital of Beijing. Tianjin occupies 11,917.3 km² and has a population of 11.76 million. The survey involved several residential sites, which were built in different years: brick courtyard housing built around 1960, mid-rise building built before 1990, and mid-rise and high-rise buildings area built after 1990.

Figure 2-2: Exit created by removing a fence

Areas built after 1990 usually have the same developer and property management company. The width of each exit and the total number of exits are restricted. In addition, the

exits are guarded and use of some are prohibited even in enclosed residential sites, negatively affecting accessibility and causing residents to break walls or fences in order to create new convenient exits. Moreover, the rapid increase in the number of cars and the fact that most residential sites have inadequent parking, illegal parking is unmanageable, especially in sites where pedistrian and vehicle access are not separated.

Residential sites built before 1990 are not operated by property management companies, and the sanitation conditions are unsightly (e.g., garbage and waste are stored excessively). These sights have lots of illegal parking and construction. Public spaces tend to be invaded by residents for private gardens or storerooms, abandoned furniture, and bicycles storage. The most distinctive feature of these types of sites is the poor construction of the infrastructure (e.g., high-risk overhead pipes).

Figure 2-3: Parking and some construction in a residential site built before 1990

Residential sites built around 1960s, which contain brick houses, face immense dangers from an earthquake due to the poor building quality and spatial arrangement. The buildings are not restricted by the safety construction code, and have a high possibility of building collapse and falling debris. After years of corrosion, these areas have the most fragile buildings, and illegal buildings with an even lower quality have been constructed. The streets in these Traditional Neighborhood areas are extremely narrow and blocked by garbage and obstacles. Most streets are not wide enough for vehicles although areas are completely open without fences.

Figure 2-4: Narrow streets blocked by garbage and obstacles in a residential site built around 1960s

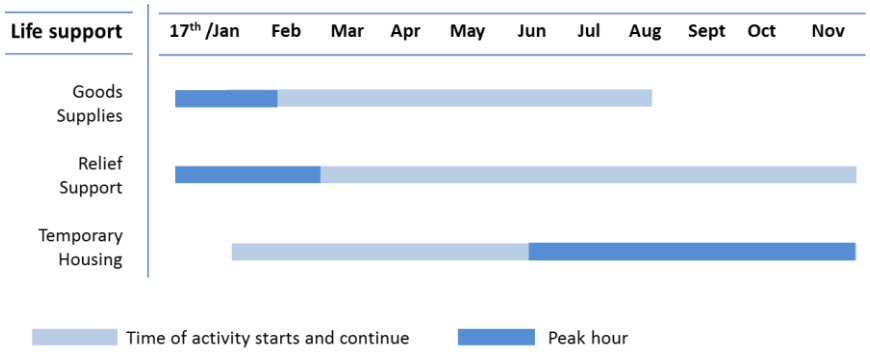
All of these issues are challenges for the earthquake disaster prevention system and pose as vulnerabilities like building collapse, fire, and difficulties during or after evacuation. Most residential areas, especially newer ones, are enclosed. Although the main avenues are safe evacuation routes, they may be inaccessible due to many issues (e.g., the massive scale of blocks and barriers like illegally parked cars and misuse of open spaces). Therefore, during an earthquake, the important role of open spaces within superblocks, which act as direct evacuation spaces, must be considered.

2.3 Changes in the demands of the open spaces after an earthquake in residential areas according to function, scale, and time sequence (Hiroko and Mifune 1997)

Sudden earthquakes are believed to cause not only widespread death but also massive disruption. Due to the main vulnerabilities in residential areas, we believe open spaces are necessary to provide evacuation routes, help evacuees avoid debris from buildings, and support relief activities. The activities depend on both the impact of an earthquake and the elasped time since the earthquake.

In the aftermath of the 1995 Great Hanshin-Awaji Earthquake (Hiroko and Mifune 1997) open spaces in parks were used to facilitate different functions at different times (Table 2-2) (e.g., at the time, temporary usage for emergency recover; at three months, short-term car parking; at six months, mid-term for goods supplement; long term, temporary housing and other relief supports).

Table 2-2: Life support requirements of the 1995 Great Hanshin-Awaji Earthquake in

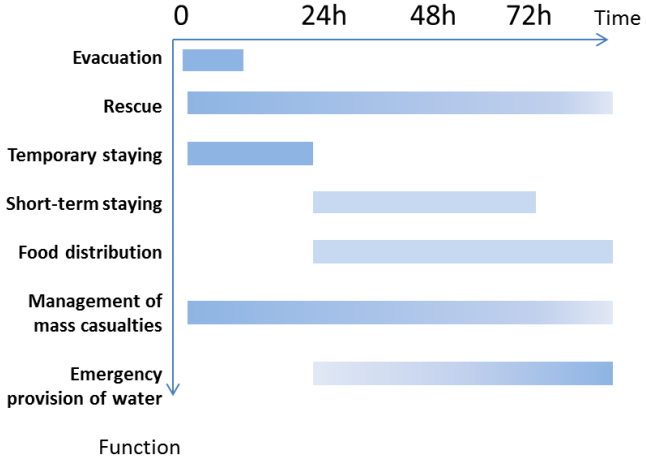


2.3.1 Relationship between time-sequence of activities and functions in open spaces

Diverese activities are generated and continued in different periods after an earthquake, changing of needs and priorities following an earthquake. Consequently, the requirements of open spaces are constantly changing (Table 2-3). Evacuation begins at the onset of the first earthquake. Evacuees tend to stay outside from the first several hours to several days in

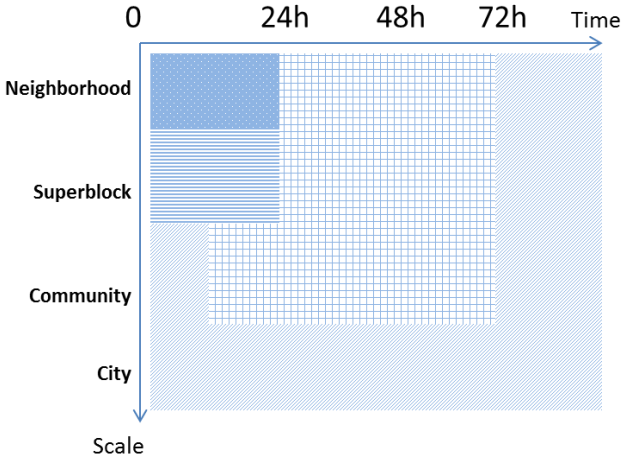
order to evade the aftershocks. Additionally, the first 72 hours are crucial for rescue, ambulance, and truck transportations. If the lifeline system is destroyed, emergency goods must be supplemented to maintain a basic life demands and residents require shelters or campsites for longer periods. When houses collapse, spaces to build temporary housing are essential.

Table 2-3: Time sequence and function required after an earthquake



2.3.2 Possible open spaces on different scales to facilitate disaster prevention in Chinese cities

Table 2-4: Time sequence and scales of open spaces after an earthquake



The urban elements are categorized into five scales according to size: building, neighborhood, superblock, community, and city. In an urban region, different levels of open spaces already exist and can provide different functions to facilitate disaster prevention (Table 2-4). Open spaces in residential sites on the neighborhood scale can support for evacuation, temporary staying, and places to distribute goods, while open spaces on the superblock scale (i.e., roads, avenues, playgrounds, and plazas) can support evacuation, temporary staying, and headquarters for rescue and transportation. On the community scale,

large parks and open space in stadiums can be used as short-term shelters, medical triage sites, parking, and places to supplement emergency goods. Urban parks and some nature resources on the city scale can function as disaster mitigation centers for storage, troops, and campsites.

2.3.3 Open spaces utilization by sequence and scales

The function of an activity and the service area dictate the size of open space required (Table 2-4). For example, the capacity, service area, and time period will differ between an evacuation site in a neighborhood and one in a community. Based on the level of damage, an evacuation may involve several steps: evacuate from buildings to open spaces then to avenues or larger open spaces, and eventually to regional sites or shelters. An open space in a neighborhood will be used immediately after an earthquake, while a community or city-scale open space will be used after the first several hours for more complex functions (e.g., shelters). On the city-scale, a disaster mitigation center, which has a larger occupied space as well as a wider service area, is often used for long-term storage of anticipated emergency goods.

Table 2-5: Functions facilitated by open spaces based on size

	Type of open space existing	Function facilitating disaster mitigation
Neighborhood	Open space in residential environment	Evacuation Temporary staying Rescue(fire engine, ambulance) Supplement
Superblock	Road, avenue Playground	Evacuation Rescue
Community	District parks City stadium	Short-term staying Rescue Supplement Shelter
city	Urban parks Green buffer	Disaster mitigation center • storage • Campsite • Army

2.4 Open spaces in superblocks

As previously mentioned, Chinese cities are divided into superblocks with wide avenues. Refuge on these avenues is recognized as a safe evacuation route, but residents may have difficulty directly assessing them. Therefore, the important role of open spaces within a superblock as a direct evacuation area must be considered. In a superblock, evacuation, rescue,

temporary staying, and emergency goods distribution are expected to be facilitated by open spaces.

2.4.1 Connection of open spaces in the superblocks

Because superblocks are considered safe places to evacuate and residential sites tend to be enclosed, the connection between open spaces inside superblocks and avenues is a major concern. The open spaces and exits must be accessible for both pedestrians and vehicles, especially rescue trucks. In addition to the available open spaces, the connection between these spaces and neighborhoods is equally important. If residents are trapped in a dangerous environment, isolated open spaces, regardless of size, may not ensure safe evacuation, temporary staying, or service area. An accessible spatial series to link open spaces together is needed because activities, especially rescue and emergency goods distribution, must be able to move freely.

Chapter 3

Concept of circulation space to evaluate earthquake vulnerability and its detection method

3 Concept of circulation space to evaluate earthquake vulnerability and its detection method

3.1 Introduction

Open spaces are an important element when discussing the quality of a living environment. Particularly in residential areas, variations in open space features provide unique characteristics as well as support airflow, natural sunlight, diverse daily activities, and disaster prevention.

In superblocks, open spaces are used in evacuation, rescue, temporary staying, and emergency goods distribution against an earthquake. Because evacuees cannot use the same routes to flee as rescue vehicles, different passages are needed to access an area from the outside. Open spaces may facilitate functions believed to exist in a circular pattern (circulation) instead of in an isolate space.

The measurement of open spaces as part of efforts to understand the functioning of open space better always undertakes with certain purpose. The methods to measure vary according to the objectives of research. The purpose of simple proximity measures, gravity models, utility and activity based model is to measure the accessibility of urban open space; Hedonic pricing model, some value analysis model of open space aims at measuring its influence on land price; [1] In current research, the key point is the distance between buildings, the purpose of measurement is to know the physical feature of each open spaces in the residential environment, therefore we need make the objective measurement of physical

[1] Appendix 1 Measurement methods of open spaces

information of the open spaces.

3.2 Definition

Circulation space identifies the continuous open spaces between buildings, which creates a passage that facilitates the free movement of people in a particular area. Movement in a circulation space can be either in or out (i.e., evacation route or access route). Additionally, a circulation space can be used to temporarily store supplies. Evacuation is the act of leaving a condition, while access means approaching a condition. Here evacuation and access represent actions corresponding to outward and inward movement, respectively.

3.2.1 Operational functions of circulation space

Circulation spaces have three main operational functions during a post-disaster period in residential superblocks: access, evacuation, and stationary support. (Ma and Ohno, Earthquake Resistant Residential Neighborhood in China: Examination of vulnerability in outdoor spaces. 2013)

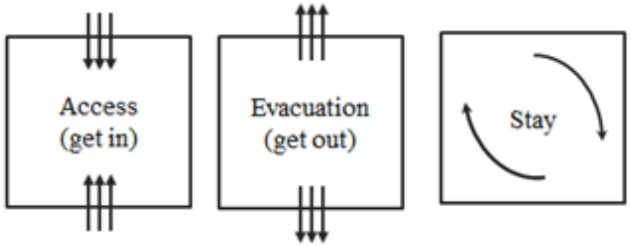


Table 3-1: Three main functions of circulation space

Access: Entering a superblock from the outside or approaching a certain location from another location of the superblock either on foot or in a vehicle.

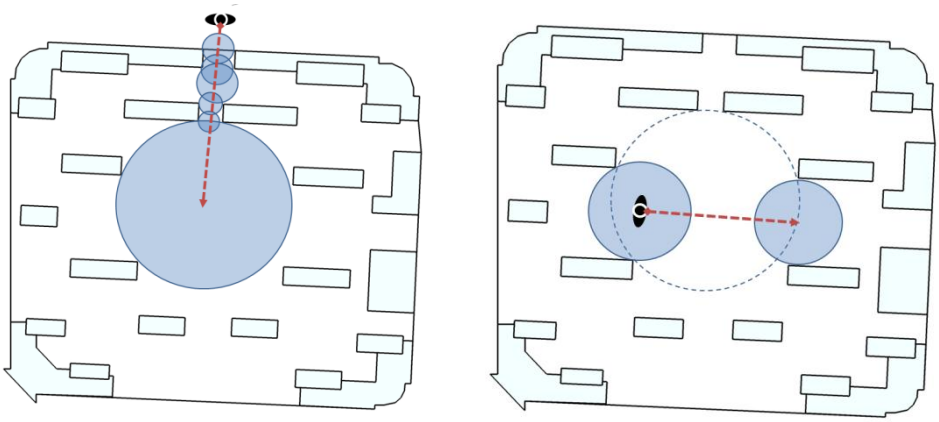


Table 3-2: Enter a superblock and shift locations in superblocks

Evacuation: Leaving a superblock to outside avenues or open spaces.

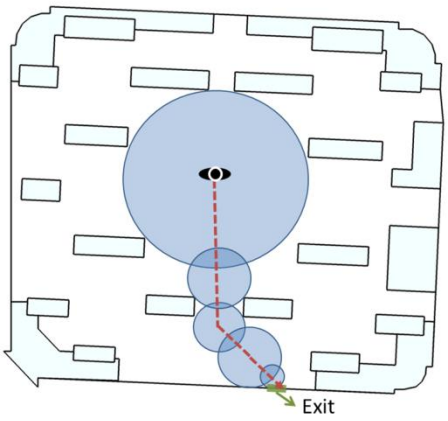


Table 3-3: Evacuate from a location inside superblock to an avenue

Stationary support: Certain activities remain in the same place, such as goods supplements or temporary staying.

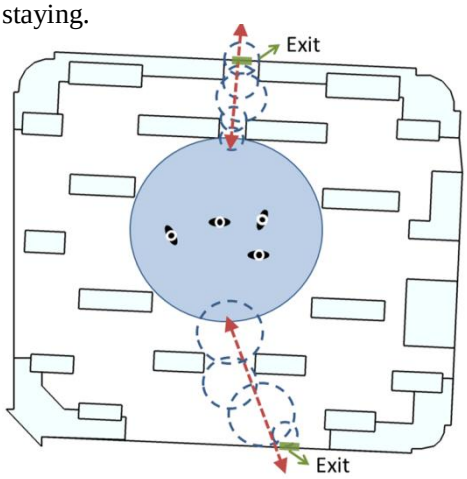


Table 3-4: Fixed location activities facilitated by double direction movement

3.3 Detection and measurement of circulation spaces

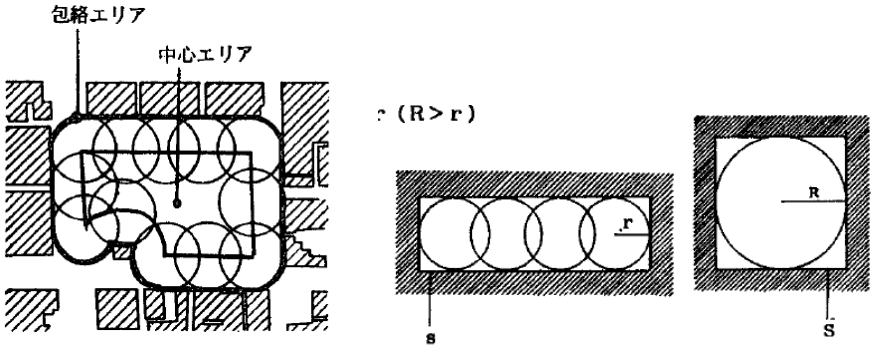
A circulation space consists of a passage to facilitate free movement of people, and numerically describing these spaces may provide insight into the degree of vulnerability. In space analysis, each open space is usually described by its distance, shape, and occupied area. Because this study generates routes between each space to create one continuous space, only basic elements of length and widths are measured in this study.

In this research, the state of circulation space is used as a criterion to evaluate earthquake vulnerabilities. However, in practice, the presence of open spaces is often represented by simple numbers, such as the percentage of open space among the total area of a city or the park area per capita. For a single open space, it is usually described by its total occupied area or its shape and two dimensional size separately. These simplified numbers cannot explain

about how well open spaces are functioning in disaster prevention, since they do not tell anything about the details and variation of open spaces itself.

3.3.1 Morphological analysis of the open spaces

Professor Gotha proposed a method to measure open spaces using morphological analysis by the largest empty circle. (Gotha 1990) The largest circle that can be placed in a certain space with a unique radius quantitatively figures out the shape of open space which hold fixed size of circle and shows the size of space (Fig. 3-5(a)). In the same size of open spaces, the radius vary depending on the shape of the space, square spaces has bigger radius than the rectangle space. (Fig. 3-5(b)) This method is used to measure the shape and size of each single open spaces.



(a) (b)

Figure 3-5: Left: Morphological analysis by the largest empty circle
Right: in the same size of spaces, Largest radius of circle changes depending on the spaces shape

In this research, we use the largest empty circle method to measure the circulation spaces since the circles are easier to access the spaces between buildings in different layout of building arrangement. Instead of using fixed radius of circles of Gota's research, circles with varying radius are used to describe the changing width of circulation space, record the changing shape and connection between each single open space. By this way, the physical information of all open spaces in certain area is detected. We record the radius in all locations of continued and accessible open spaces. The shortest circulation route is then

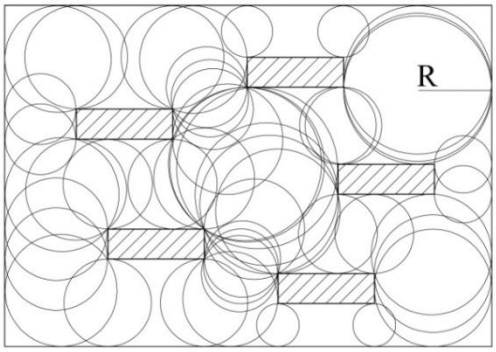


Figure 3-6: Circulation spaces

plotted by connecting the center of each circle. The shortest circulation route is then plotted by connecting the center of each circle.

3.4 Automatic detection of circulation routes by programming and its application

There are various of size and shape of circulation spaces in a particular area by the layout of buildings and exits. An automatic method of detection could help us to accurately capture the circulation spaces and record the numerical data. A programming using an Auto CAD application is attempted in this research.

When a person enters a particular space from an entrance or remains at a location in the space, our program measures the smallest usable space by drawing a circle where the person is the center and the distance to the nearest object is the radius. If a person is moving, the radius changes. In this manner, circles for all positions in the target area can detect the spaces between buildings.

Routes can be generated based on the drawn circles. Among the many options for circulating in the target area, the most effective evacuation route is important in an emergency situation. This route can be detected by connecting the centers of circles following certain principles.

3.5 Detection of circulation route --Programming detail (Ma and Ohno 2013)

The CAD (computer-aided design) system, which has been applied to recent designs and the architecture industry, uses vector graphics. CAD describes and simulates a solid physical model on a computer, which is between the real condition and electronic data, and can support both 2D and 3D formats.[18] AutoCAD supports a number of APIs (Application Programming Interfaces) for customization and automation. AutoLISP is a dialect of the Lisp (List Processor) programming language built specifically for use with AutoCAD and its derivatives. Aside from the core language affording mathematical and function operations, most of the primitive functions are for geometry, accessing an internal DWG database, or manipulating graphics in AutoCAD. AutoLISP code can be entered at the command prompt or loaded from external files.

The CAD map records the vector information of each target area. We have developed a program, which is applied by AutoLISP, to detect the circulation spaces, automatically plot the emergency routes, and determine the space characteristics.

3.5.1 Rules

In our program, several rules must be followed to draw the map. Firstly, an enclosed boundary is required. Secondly, because our program setting only recognizes straight lines (not arches, circles, or curves), all single lines exist in only one closed polygon where the interior angle between the end points of two lines does not equal to 180 degrees. Thirdly, each polygon (building) is set as one object while the boundary of the area is set as one single object.

3.5.2 Possible cases to define a circle[2]

All lines and points, which represent buildings, are classified into groups by polygons; each object is marked by the coordinates of its all points, such as [(p1,p2,p3,p4)(p5,p6,p7)…… (pn,…,px)]. Circles are used to measure the spaces between buildings. Different scenarios can be used to draw a circle (Fig. 3-7 and Fig.3-8). However, all drawn circles must meet one basic condition: the circle cannot cross another object.

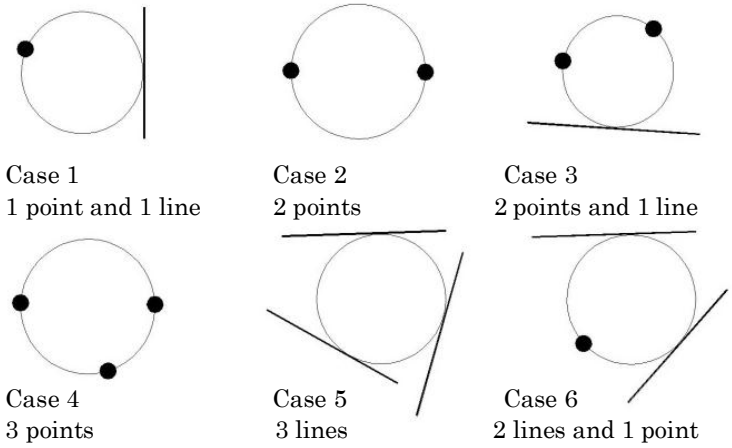


Figure 3-7: Possible scenarios to define a circle

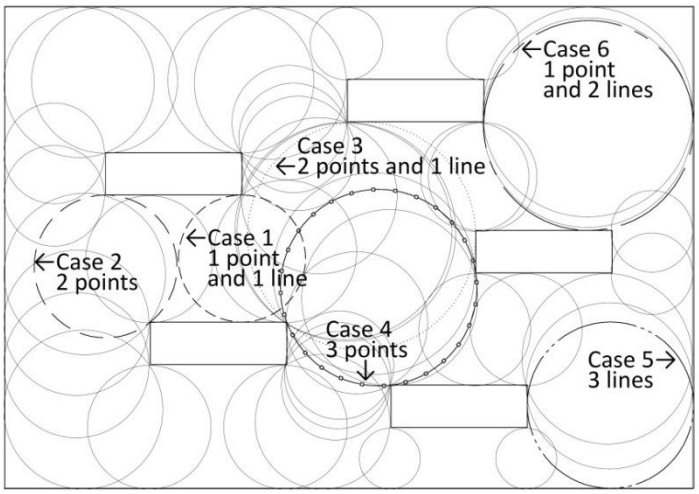


Figure 3-8: Possible scenarios to define a circle in the sample site

[2] Appendix 5 Auto CAD programming 1 – Draw circles

Case 1: Circle passing through one point and one line

To select an object, line L1 and point P1 (p1,p2,p3,…,px) must not belong to the same object. Draw a vertical line from any point P (p1,p2,p3,…,px) to the line that belongs to the other object (Fig. 8). Assume the vertical line is the diameter of the circle. A perpendicular point exists inside the line instead of on the extension line.

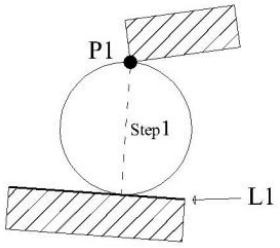


Figure 3-9: Drawing process for Case 1

In another situation, extend the lines that share the same point P1 in the direction where the intersection is potentially exist with the straight line L1 (Fig. 9). Find one point on the extension line such that the distance to the initial point equals the distance with the straight line.

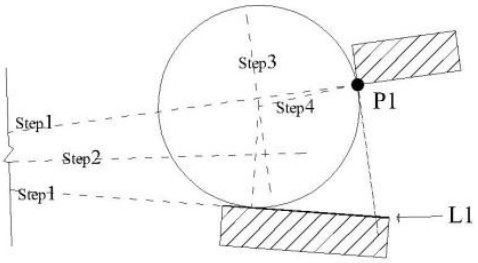


Figure 3-10: Drawing process for Case 1

Case 2: Circle passes through two points

Connect any two points P1 (p1,p2,p3,…,px) and P2(p1,p2,p3,…,px) (Fig. 10). The connection line is the diameter of the circle.

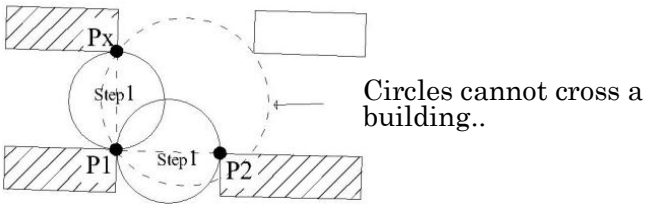


Figure 3-11: Drawing process for Case 2

Case 3: Circle passes through two points and one line

To select an object, points P1, P2, and line L1 must be in the same object (Fig. 12). The connection line of two points P1 and P2 must not parallel to line L1 and does not cross line L1. Extend the line and the connection line to an intersection. Draw an angular bisector to connect the perpendicular bisector of the two points. Find the point where the distance to the other point (P1 or P2) is equal to the distance to the line L1 along the perpendicular bisector.

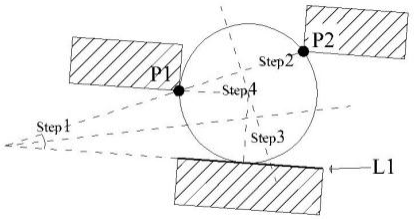


Figure 3-12: Drawing process for Case 3

Case 4: Circle passes through three points

To select an object, the three points P1, P2, and P3 must not be in the same object, although two points can be from the same object (Fig. 13). Draw straight lines to create line segments for any two pairs of the points. Find the perpendicular bisector of two lines. Their intersection is the center of the circle. The distance between the center and any point (P1, P2, P3) is the radius of the circle.

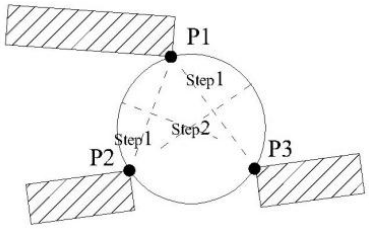


Figure 3-13: Drawing process for Case 4

Case 5: Circle passes through three lines

(case5.1) Three straight lines: To select an object, only two of the three lines (L1, L2, L3) can be in the same object (Fig. 14). Extend the three lines until intersection points appear. Take the intersection of the three angular bisectors as the center. The distance to any line is the radius of the circle. The tangent point must be on the line instead of on the extension line.

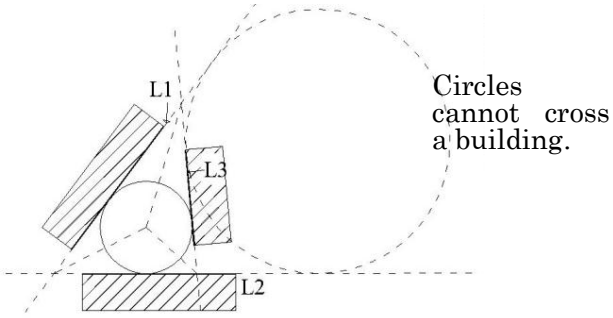


Figure 3-14: Drawing process for Case 5

(case5.2) Two parallel lines and one straight line: Take the distance between two parallel lines L1 and L2 as the diameter (Fig. 15). Draw the perpendicular bisector of the third straight line L3. Find the point on the bisector where the distance equals the radius of the center of circle. The tangent point must on the line instead of on the extension line.

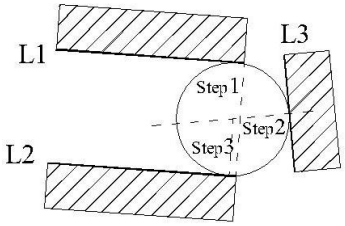


Figure 3-15: Drawing process for Case 5

Case 6: Circle passes through one point and two lines

To select an object, all lines (L1, L2) and point P1 must not be in the same object, and the point is not on a line (Fig. 16). Extend the lines to an intersection. Draw an angular bisector. Find a point on the angular bisector where the distance to the line equals with the distance to the point Px. The tangent point must exist on the line instead of on the extension line.

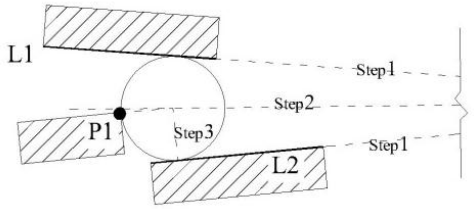


Figure 3-16: Drawing process for Case 6

3.5.3 Data output

As shown in Table 1, data is recorded as three text files. File 1 is for the serial number of each circle and includes the coordinates of the center of circle and its radius. File 2 records how many objects are tangent to the circle as well as the serial number of those

objects. File 3 is a list denoting the initial row of the data for each circle in File 2.

Table 3-1. Output of the data files

Data	File 1	File 2	File 3
Content	Coordinates of the center of circle/radius	Number of connected object (1 row)/ Serial number of connected object	Initial row in File 2
C1	(Xc1, Yc1) R1	3(objects)	1
		5	
		9	
		21	
C2	(Xc2, Yc2) R2	2(objects)	4
		5	
		15	
…	…	…	…
Cx	(Xcx, Ycx) Rx	3(objects)	X
		2	
		7	
		10	

3.5.4 Drawing route lines

To detect the routes between buildings, connect the centers of the circles. This process produces two situations.

Circles in contact with two objects

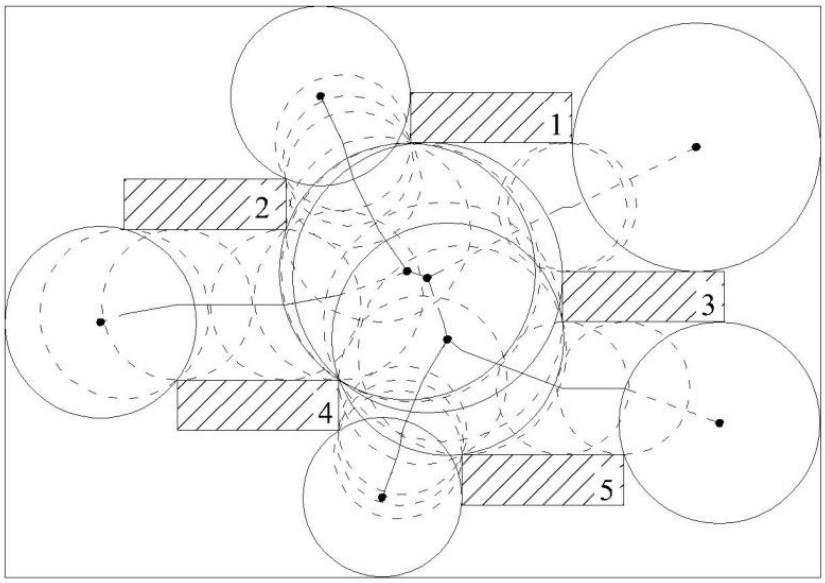
Pick circle C1 with its serial number through File 1. Read which two objects are in contact with the circle using File 2 and File 3. Choose all the circles that also touch only the same two objects, and sort the distance between centers with C1 from the shortest to the largest.

Connect the center of C1 with the first and second shortest distances, which are the expected route segment (Fig. 3-17). The connection line between two circles cannot cross any object or fully cut another circle. Repeated lines are read only once in the final result.

Circles contact with three objects:

When circle P1 is in contact with three objects, circles that share any two objects (including circles that only connect to two objects) must be read using File 2 and File 3. Similar to the previous situation, repeat this process (Fig. 3-17). Starting points and exits

must be manually set when running this program.[3]



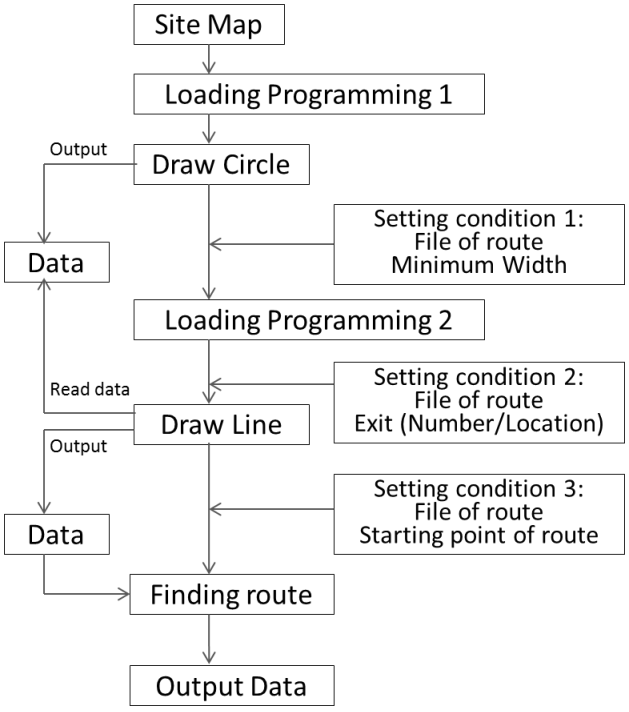
Step 1: Connect the route from circles that touch two objects

Step 2: Connect the route from circles that touch three objects

Figure 3-17: Process to draw lines

3.5.5 Running flow

Table 3-2: Flowchart from drawing the sitemap to determining the route



Appdendix 1

Appendix 2

Appendix 3

[3] Appendix 6 Auto CAD programming 2 – Connect circulation routes

3.6 Results and basic application

The final direct output data of this program divides the two nearest circles into a circulation route into groups. The radius of two adjacent circles (width of circulation spaces) and the distance between the centers of circles are recorded as numerical data.

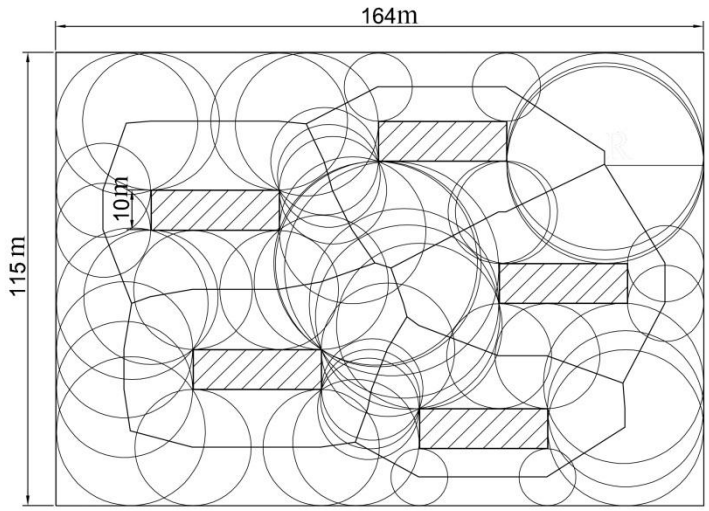


Table 3-18: Sample area for program testing

A calculation plug-in based on Excel is used to determine the length of a circulation route within the required range of width. Counting the accumulative length of the routes describes the space characteristics. Thus, calculating the lengths and widths of the routes can be used as a criterion to evaluate open spaces.

We measure the circulation routes by category of radius which set as every 3 meters difference to record the length of the route that belongs to each radius category. Figure 3-17 shows the program results for the sample site occupying a 115-m by 165-m area with five buildings with depths of 10 m randomly laid out. The program detected all the open spaces in the circuit and automatically connected the circulation route. Figure 3-19 shows the lengths of circulation routes with different widths in the sample area. The longest circulation routes occurred with a width between 30 and 40 m. 300 meter of circulation route in the width of 30- 40 meter holds almost half of the total route length (Fig 3-20).

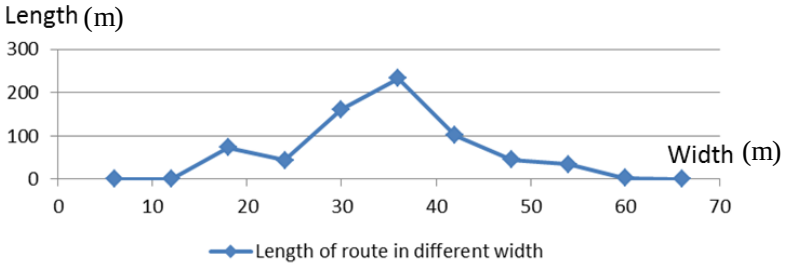


Figure 3-19: Length of circulation spaces with various widths

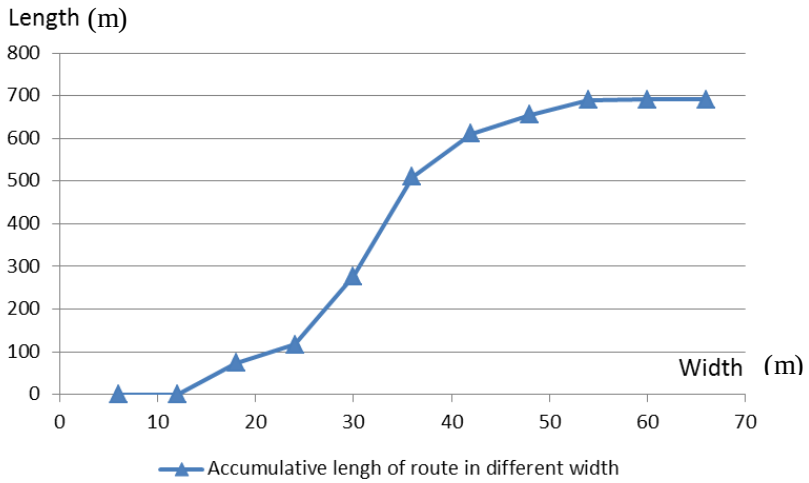


Figure 3-20: Accumulative length of various circulation spaces

3.6.1 Application to evaluate the vulnerability against earthquake disaster

Using this method, the vulnerability of residential areas can be evaluated against earthquake disasters. Although the impact of falling debris is uncertain after an earthquake, our program considers different scenarios to analyze how the space between buildings changes as the damage becomes more severe.

The intended usage dictates the minimum required width. For example, routes for fire engines must be at least four meters wide. Our program can evaluate the width of spaces to determine possible routes for different applications as well as measure the usable space for temporary gatherings or to distribute emergency supplies. Consequently, our program can identify key locations for specific functions.

3.7 Conclusion

This AutoCAD programming application can assess open spaces between buildings and automatically provide numerical data. The conditions can be specified, which is useful for various space analyses under different scenarios. This method was applied to examine vulnerabilities against an earthquake in a residential environment and provide numerical measures for an objective evaluation. This is a new approach using evidence-based design to study environmental quality.

Chapter 4

Analysis of the physical characteristics of the circulation space for earthquake disaster prevention in superblocks

4 Analysis of physical characteristics of circulation space for earthquake disaster prevention in superblocks

4.1 Introduction

The distribution of various sizes of circulation spaces within superblocks provides an evaluation criterion to assess earthquake disaster prevention performance. The physical characteristics of the superblocks can provide insight into the capability of earthquake prevention under different conditions.

4.1.1 Objective

Each residential neighborhood in a superblock has its own unique physical features, which influence the requirements of disaster prevention. Analysis of the physical characteristics of the circulation space can be used to determine vulnerabilities of earthquake disaster prevention in different residential environments.

The actual situation in a residential environment is also important to detect circulation spaces. All of the elements in a real environment may affect how circulation spaces are utilized. For instance, higher buildings may cover a larger area with debris, while parking may restrict the circulation. The ground truth for each particular site is helpful in creating a more precise evaluation for disaster prevention.

4.1.2 Variations due to damage level

Besides the physical characteristics of a residential environment, the damage level greatly impacts disaster prevention. Not only geological effects, such as soil liquefaction

and topographical changes, but structure failure and debris-covered area are directly influenced by the earthquake intensity. Consequently, the circulation capability shifts under different earthquake scenarios in the same area. Therefore, the damage level is an essential component in the analysis of circulation spaces.

4.2 Site selection

To understand the actual situation of residential environments, we conduct a case study in the Municipal of Tianjin. Tianjin is located on the north China seismic belt, and is 120 km from the capital of Beijing. The municipality covers 11,917.3 km² and has a population of 11.76 million. (Government of Tianjin 2012)The city has experienced five earthquakes with a magnitude over 7.0, including the 1976 Tangshan earthquake that resulted in over 250,000 fatalities.

4.2.1 Site selection rules according to the urban texture

In urban areas of Chinese cities, avenues divide spaces into superblocks, which have their own identities. The characteristics of the urban texture in terms of building structure, building density, height, and size are similar within a single superblock or between of several superblocks. Therefore, superblocks can easily be categorized into different types according to their urban texture. From a historical perspective, the city of Tianjin contains five types of residential superblocks:

1) High-rise building (HB): Constructed after 1990, high-rise building superblocks have concrete and shear wall structures with an average height of 40 meters.

Figure 4-1: High-rise building superblocks

2) New mid-rise building (NM): Constructed after 1990, new mid-rise building superblocks are comprised of concrete and shear wall structures with an average height below 24 meters.

Figure 4-2: New mid-rise building superblocks

3) Old mid-rise building (OM): Constructed before 1990, old mid-rise building superblocks contain masonry structures with an average height below 21 meters.

Figure 4-3: Old mid-rise superblocks

4) Historical concession area (HC): Constructed around 1860-1990, historical concession area superblocks are composed of masonry structures with an average height below 10 meters. Historical concession area is built during the colonial era started from 1860.

Figure 4-4: Historical concession superblocks

5) Traditional neighborhood (TN): Constructed before 1990, traditional neighborhood superblocks are made up of brick structures with an average height below 5 meters.

Figure 4-5: Traditional neighborhood superblocks

Similar sized areas were analyzed and compared for the five types of superblocks. Each analysis area was about eight hectares, except for the traditional neighborhood superblock. Because the traditional neighborhood superblock had an intense spatial organization, the analysis area was about half a hectare.

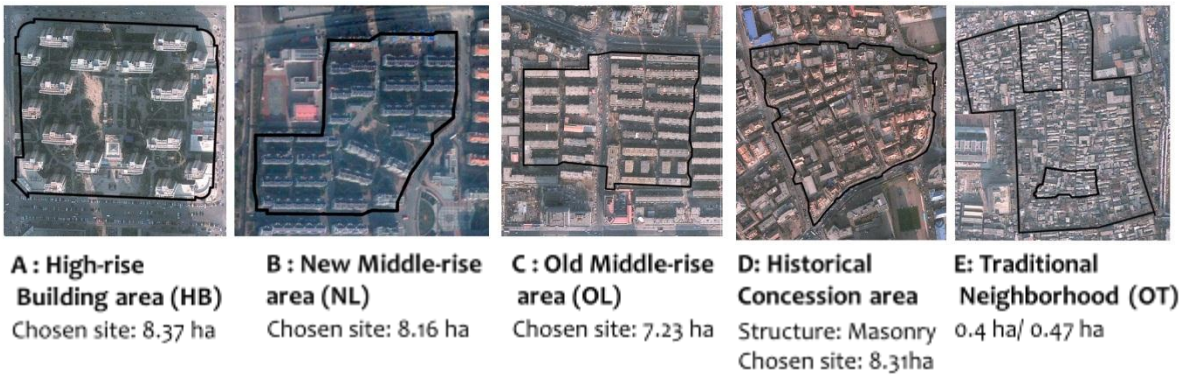


Figure 4-6: Selected sites for the five types of residential areas

4.3 Survey procedure

We conduct a field survey in the selected sites to collect both onsite data and demographic data. The onsite survey tried to observe all the trivial elements in each particular area, which were then used to track records both for original building information and the influence of people on the environment. In addition to determining the effect of circulation elements in the residential environment, this data was the basis for site mapping.

4.3.1 Onsite survey

The onsite survey aimed to map the site and to examine potential vulnerabilities through a checklist. Although it was expected that the survey results would provide details of the target area and remedy the elements that could not be obtained through two-dimensional observations, high-definition satellite images were used to develop a map

of the building layout. Then survey results were used to create the site maps based on the satellite images. Resolution of site map is set as millimeter (1/1000 meter).

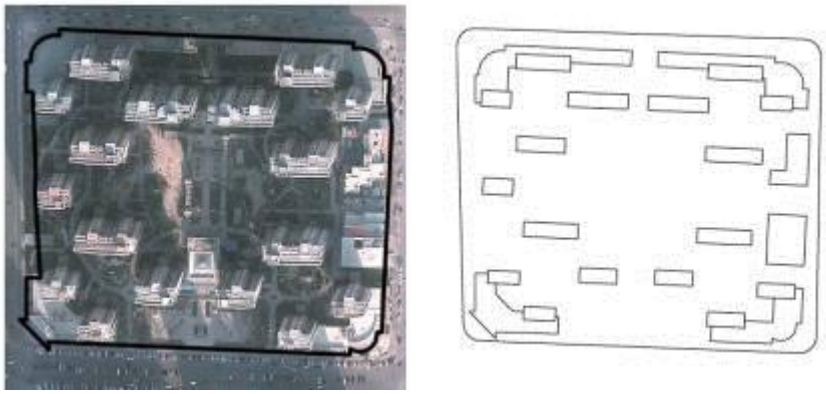


Figure 4-7: Layout of a target site via a satellite image (High-rise building superblock)

	Items		Detail	Description	Number of photo
	Building	Building quality			
		Wall			
		Roof style			
		Possible debris			
		Usable facility			
	Possible cause of danger	Barrier			
		Illegal constructions			
		Infrastructure: Electricity/Heating station			
		Others			
	Elements of road	Car parking spot			
		Car parking (illegal)			
		Green			
		Others			
	Type of road	Pedestrian only/ Mix			
		Width			
	Green area	Tree species			
		Height			
		Location			
	Accessibility	Fence/Wall			
		Number of exit			
	Others				

Mapping data
Environment data
Reference
Others

Table 4-2: Checklist for the onsite survey

Table 4-3: Procedure for mapping the concession area

We divided the observation target into four parts in the survey checklist: buildings, structures, roads, and plants. A checklist accompanied the detailed route map, which listed the observation points within each group. Although the site map could include different elements, the current research used buildings, possible causes of danger, and accessibility information in the final sitemap as elements. The building information consisted of building quality, possible debris, roof style, and special function buildings or spaces.

Environmental elements (e.g., parked cars and landscaping) affect the circulation efficiency. The onsite observations detected potential vulnerabilities and aided in developing effective proposals for disaster prevention. Thus, future research should include this type of

environmental elements in the analysis.

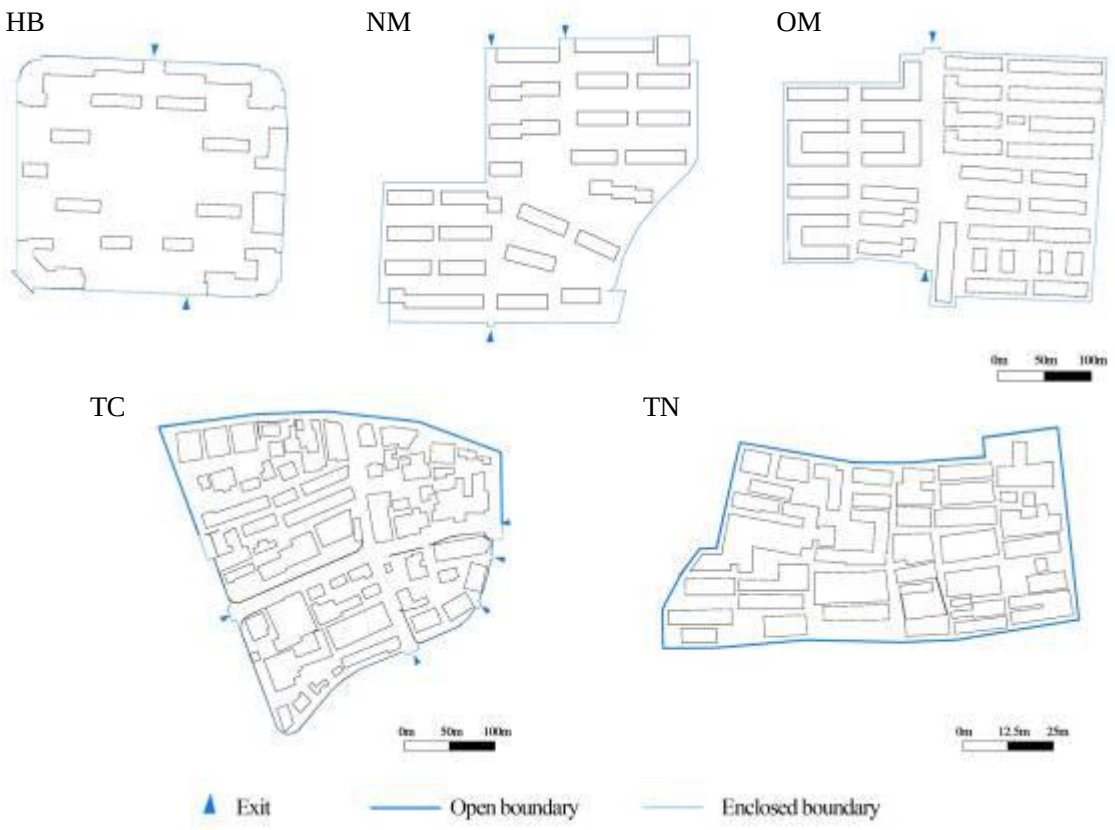


Figure 4-8: Final site maps of the target areas representing the five types of superblocks

4.3.2 Physical characteristics of the residential areas via the onsite survey

The onsite survey indicated the characteristics of each type of residential area because the features of residential buildings and the environment influence spatial circulations.

Figure 4-9 High-rise building area

The risk of building collapse due to an earthquake for high-rises built with a concrete-steel frame is very low. The largest threat is from falling debris during evacuation, especially from facades with large windows and glass. Higher buildings impact a larger area because taller buildings shake more.

In Chinese cities, one classic layout is high-rise buildings with wide-open spaces in the

middle, while the boundary is enclosed by commercial buildings. In this arrangement, pedestrians and vehicles are separated. There is only one ringed road and two entrances wide enough for cars to pass in an emergency situation. Parking spaces are located underground, which may raise some concerns about the ground floor of the structure. In this particular site, the northeast corner contains a kindergarten and a large power station.

Figure 4-10: New mid-rise building area

New mid-rise buildings are classified as buildings under 21 meters and built after the 1990s. Most are constructed as concrete shear wall structures, which has a low probability of collapse. The layout is severely restricted by the planning guidelines, and the buildings are arranged parallel. The selected site is semi-enclosed where openings serve as both entrances and exits. Potential danger is due to debris from illegal construction and unreasonable utilization of the balcony spaces. Vehicles and pedestrians are mixed, which leads to issues with illegal parking; cars and bicycles are randomly parked on streets, blocking evacuation routes.

Figure 4-11: Old mid-rise building area

The old mid-rise building area contains masonry structures built before the 1990s. Although the layout is similar to the new mid-rise building area, the old mid-rise building quality is inferior because it is not confined by the new guidelines. Besides the common weaknesses of mid-rise building areas (e.g., illegal parking and construction), the most distinct feature of the chosen site is the poor construction of the infrastructure. For example, the overhead pipes are high risk. Additionally, the only entrance is narrow, making evacuation more difficult. Due to the lack of management measures, the sanitation conditions are unsightly; garbage and waste are stored excessively. The residents have invaded public spaces using them as private gardens or storerooms, while the parks are full of abandoned furnishings and bicycles.

Figure 4-12: Historical concession area

The concession area built before 1900 by European architects is a unique type of superblock in Tianjin. This area is comprised of well-maintained low-rise buildings with sufficient space between buildings to create a scale-friendly environment. The whole site is openly connected to the urban road system, but fences and walls divide the blocks into small yards, which may decrease options for evacuation routes.

Figure 4-13: Traditional neighborhood

The Traditional Neighborhood is mostly brick houses built by the residents themselves around the 1960s. Earthquake damage poses an immense danger due to both the building quality and spatial arrangement. Because the buildings are not restricted by a safety construction code, there is a high likelihood of building collapse and falling debris. After years of corrosion, the buildings are more fragile than in other areas, and shoddily constructed illegal buildings are everywhere. In addition, the streets are extremely narrow and blocked by garbage and obstacles; most are not wide enough for vehicles to use.

4.4 Detection of circulation spaces and analysis of the results

Using the Auto CAD program, the open spaces in the residential environments are assessed. The circulation spaces are detected as well as the circulation routes are connected and recorded. Using the basic data from programming analysis, both the physical features of the circulation spaces and behavior issues are applied to examine vulnerabilities via a numerical approach. Through the differences of the circulation space performance in different area, the evaluation could be concluded.

4.4.1 Circulation spaces based on the a damage situation

The damage situation influences circulation performance. Understanding the situation for different damage levels is important to evaluate the stability and flexibility of circulation

spaces and to determine the characteristics of circulation spaces.

The largest vulnerability of Chinese residential area is falling debris, which affects the actual circulation spaces when an earthquake occurs. Debris includes glass, exterior decorations, and fragile structures from buildings. The area impacted by debris increases as the earthquake intensity and building height increase, weakening the circulation spaces and restricting the required functions for disaster prevention. Consequently, understanding the impact of the damage situation on circulation spaces should allow the vulnerabilities of different types of residential areas to be assessed.

To deduce the amount of shaking and the debris-affected areas, building strength and seismic movement are major factors. Due to the lack of information regarding building strength, the damage is represented as the debris-covered area relating with the EMS (1998) code. (Building strength data based evaluation is expected in the future research.)

The European Macroseismic Scale (EMS)[4] is the basis for evaluation of seismic intensity in European countries. The European Macroseismic Scale EMS-98 is the first seismic intensity scale designed to encourage co-operation between engineers and seismologists, rather than being for use by seismologists alone. Unlike the earthquake magnitude scales, which express the seismic energy released by an earthquake, EMS intensity denotes how strongly an earthquake effects on humans, objects and nature, as well as damage to buildings. The European Macroseismic Scale has 12 divisions, as follows:

Table 4-4 European Macroseismic Scale (working group macroseismic scales 1998)

Level		**Effects on humans**	**Effects on objects and on nature**	**Damage to buildings**
I	Not felt	Not felt by anyone.	No effect.	No damage.
II	Scarcely felt	Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.	No effect.	No damage.
III	Weak	The earthquake is felt indoors by a few. People at rest feel a swaying or light trembling.	Hanging objects swing slightly.	No damage.
IV	Largely observed	The earthquake is felt indoors by many people, outdoors by few. A few people are awakened. The level of	Windows, doors and dishes rattle. Hanging objects swing	No damage.

[4] Appendix 2 classifications used in European Macroseismic Scale

		vibration is possibly frightening		
V	Strong	The earthquake is felt indoors by most, outdoors by many. Many sleeping people awake. A few run outdoors.	Entire sections of all buildings tremble. Most objects swing considerably. China and glasses clatter together. The vibration is strong. Topheavy objects topple over. Doors and windows swing open or shut.	No damage.
VI	Slightly damaging	Felt by everyone indoors and by many to most outdoors. Many people in buildings are frightened and run outdoors	Objects on walls fall.	Slight damage to buildings; for example, fine cracks in plaster and small pieces of plaster fall.
VII	Damaging	Most people are frightened and run outdoors.	Furniture is shifted and many objects fall from shelves.	Many buildings suffer slight to moderate damage. Cracks in walls; partial collapse of chimneys.
VIII	Heavily damaging	Most people are frightened and try to run outdoors. Many find it difficult to stand, especially on upper floors. Can be noticed by people driving cars.	Furniture may be overturned. Objects fall from shelves n large numbers. Water splashes from containers, tanks and pools.	Many to most buildings suffer damage: chimneys fall; large cracks appear in walls and a few buildings may partially collapse.
IX	Destructive	General panic. People may be forcibly thrown to the ground.	Many monuments and columns fall or are twisted. Waves are seen on soft ground.	Many ordinary buildings partially collapse and a few collapse completely. Windows shatter..
X	Very destructive			Many buildings collapse. Cracks and landslides can be seen
XI	Devastating			Most buildings collapse
XII	Completely devastating			All structures are destroyed. The ground changes

Here we assume that the severity of debris increases in increments of 10% of a

building's height. For example, debris-covered areas of 10%, 20%, and 30% of a building's height are defined as damage levels of 1, 2 and 3, respectively.

10% of building's height debris-covered area is taken as an equivalent of about EMS level VI - Slightly damaging, for example, fine cracks in plaster and small pieces of plaster fall.;

20% of building's height debris-covered area is about EMS level VII – Damaging, such as partial collapse of chimneys;

30% of building's height debris-covered area is assumed as EMS level VIII – Heavily damaging: chimneys fall; large cracks appear in walls and a few buildings may partially collapse.

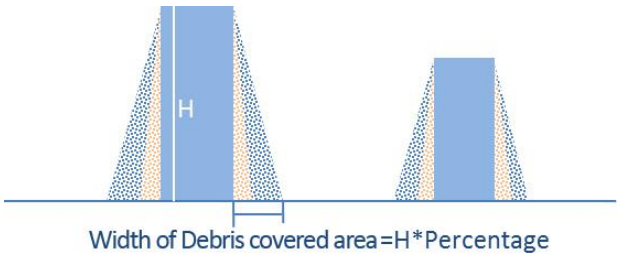


Figure 4-14: Debris covered area is estimated as a function of building's height

4.4.2 Changes in circulation spaces at different sites

Using the CAD program, the physical characteristics of circulation spaces are described. We categorized the circulation routes using the radius, where a new category is defined by a three-meter difference. Then the route lengths for each category are recorded. Resolution of this calculation is 1 meter.

In the high-rise building area, the debris area is large due to building height (60 m). The majority of the circulation space in normal situations are between 20–60 m (radius 10–30 m), but once damage is sustained, the spaces are reduced to 20–40 m. When the damage reaches damage level 2 (effect area is 20% of a building's height), the accumulative length of circulation space is reduced from 1700 m to 1150 m, and one exit is blocked. When the damage reaches damage level 3 (effect area is 30% of a building's height), evacuation will be forbidden because all the exits will be blocked (Fig. 4-18). (Ma and Ohno, Development of a method to measure outdoor space using an AutoCAD application. 2013)

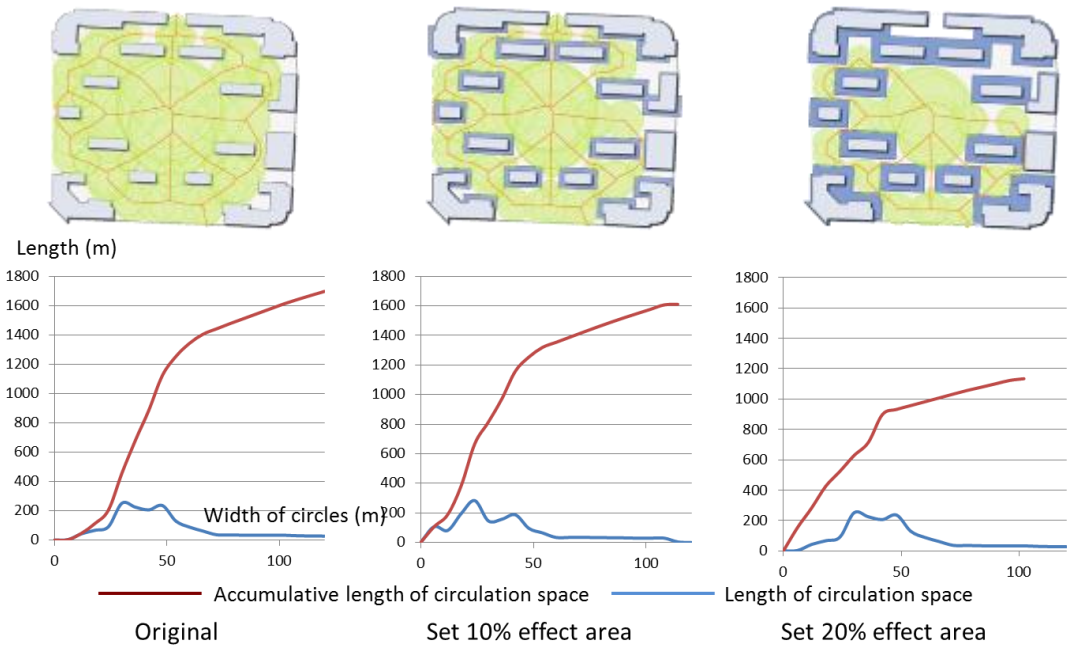


Figure 4-15:
Changes in the circulation space according to different damage situations in the high-rise building

The circulation space in the new mid-rise building area has a length is about 3300 m in normal situations as well as at damage levels 1 and 2, but is reduced to 3000 m for damage level 3. At the same time, the width of widest circulation space changes from 65 m to 55 m at damage level 3 (Fig. 4-19).

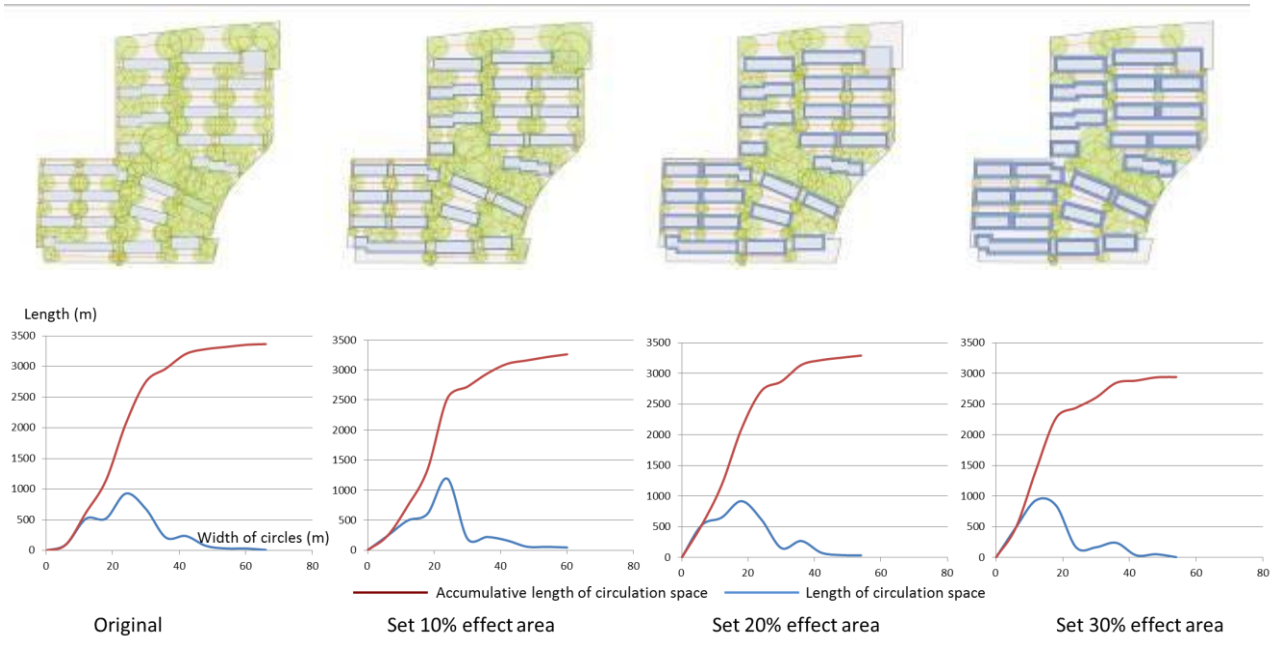


Figure 4-16:
Changes in the circulation space according to different damage situations in the new mid-rise building area

The old mid-rise building area has an almost 4000 m longest circulation route in normal situations. Although the change at damage level 2 is small, for damage level 3 the longest circulation route is 1200 m, which is one-third of the original route (Fig. 4-20).

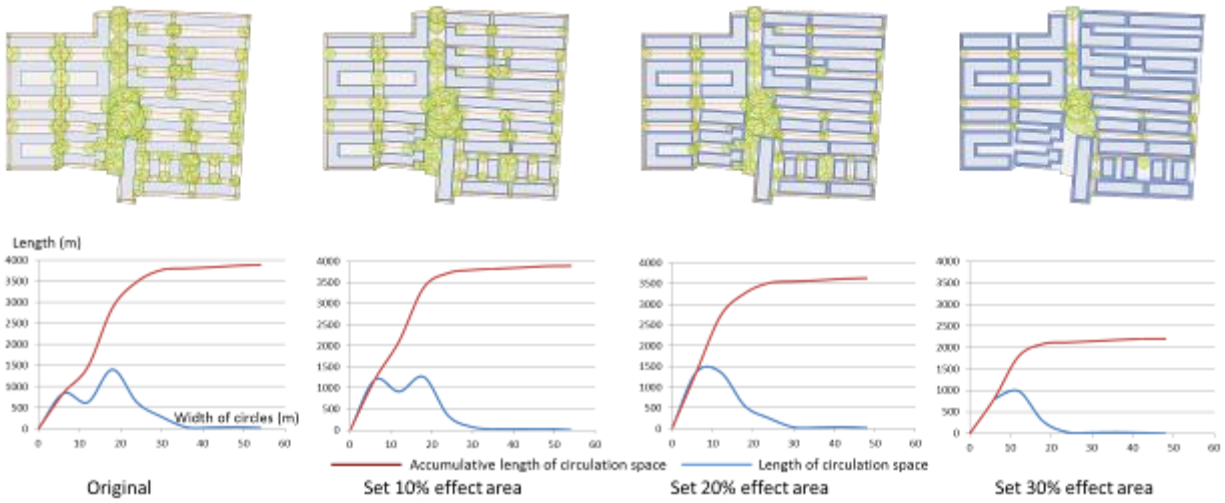


Figure 4-17:
Changes in the circulation space according to different damage situations in old mid-rise building area

The historical concession area has a relatively long but narrower circulation space. The debris-covered area is narrow because buildings are less than 10 m tall. The accumulative length of circulation space exceeds 5000 m in normal situations and damage level 1, but the effects increase for damage level 2 (Fig. 4-21).

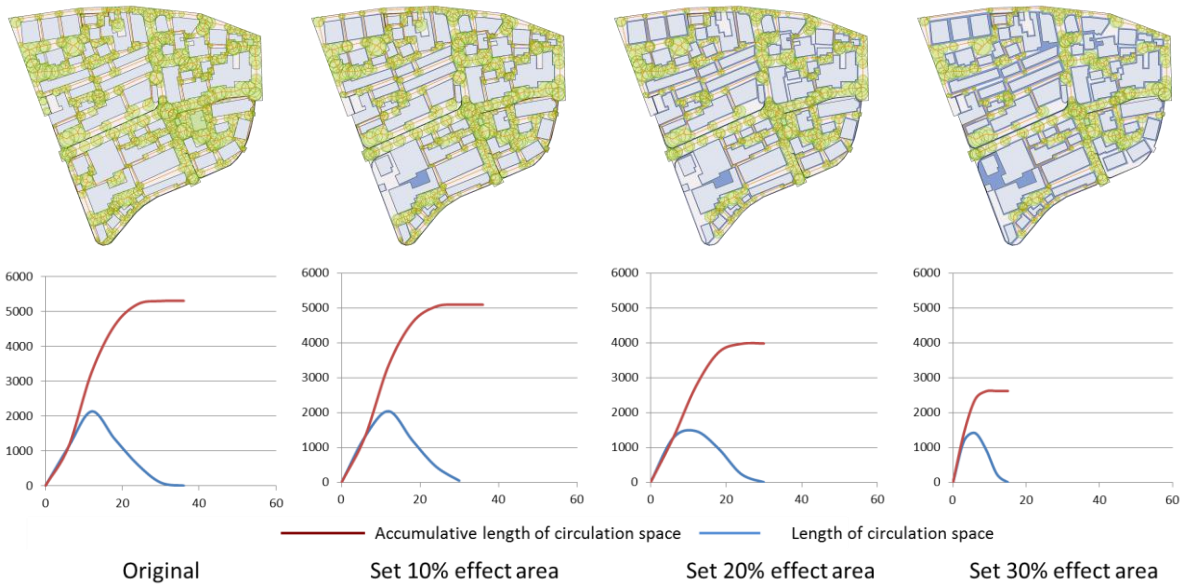


Figure 4-18:
Changes in the circulation space according to different damage situations in the high-rise building

In the traditional neighborhood, the results are estimated based on the analysis of sample site, which is 1/20 of the total area. The circulation space in this area has distinguishing features, such as very long but extremely narrow routes. Although the circulation route exceeds 10000 m in length under normal circumstances, the width is less than 6 m. The damage situation greatly impacts the circulation. The circulation space is cut in half for damage level 2 (Fig. 4-22).

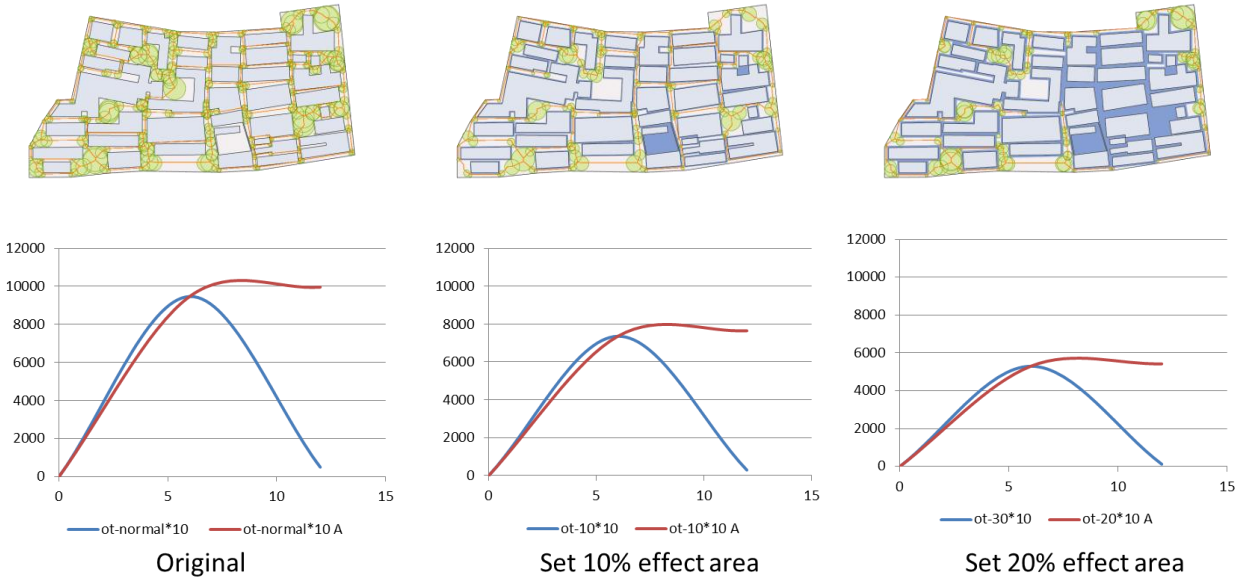


Figure 4-19:
Changes in the circulation space according to different damage situations in the traditional neighborhood

Using the accumulative length and widths of the circulation spaces provides a better understanding of the influence of different damage situations in the five types of neighborhoods (Fig. 4-23). The high-rise building area possesses the widest circulation path, which is significantly altered at damage level 2. The new mid-rise building area has the most stable performance; damage level 2 has a negligible effect on the circulation space, while damage level 3 has a small impact. The old mid-rise building area has similar tendencies as the new mid-rise building area up to damage level 2, but the influence of damage level 3 cuts the circulation space in half. The historical concession area shows a dense pattern with more than 5000 m in length and under 40 m wide, and the impact is obvious for damage level 2. The traditional neighborhood area is the most unique; it is extremely dense with a long but very narrow circulation route. Consequently, the traditional neighborhood is the most vulnerable and suffers the most for all damage levels.

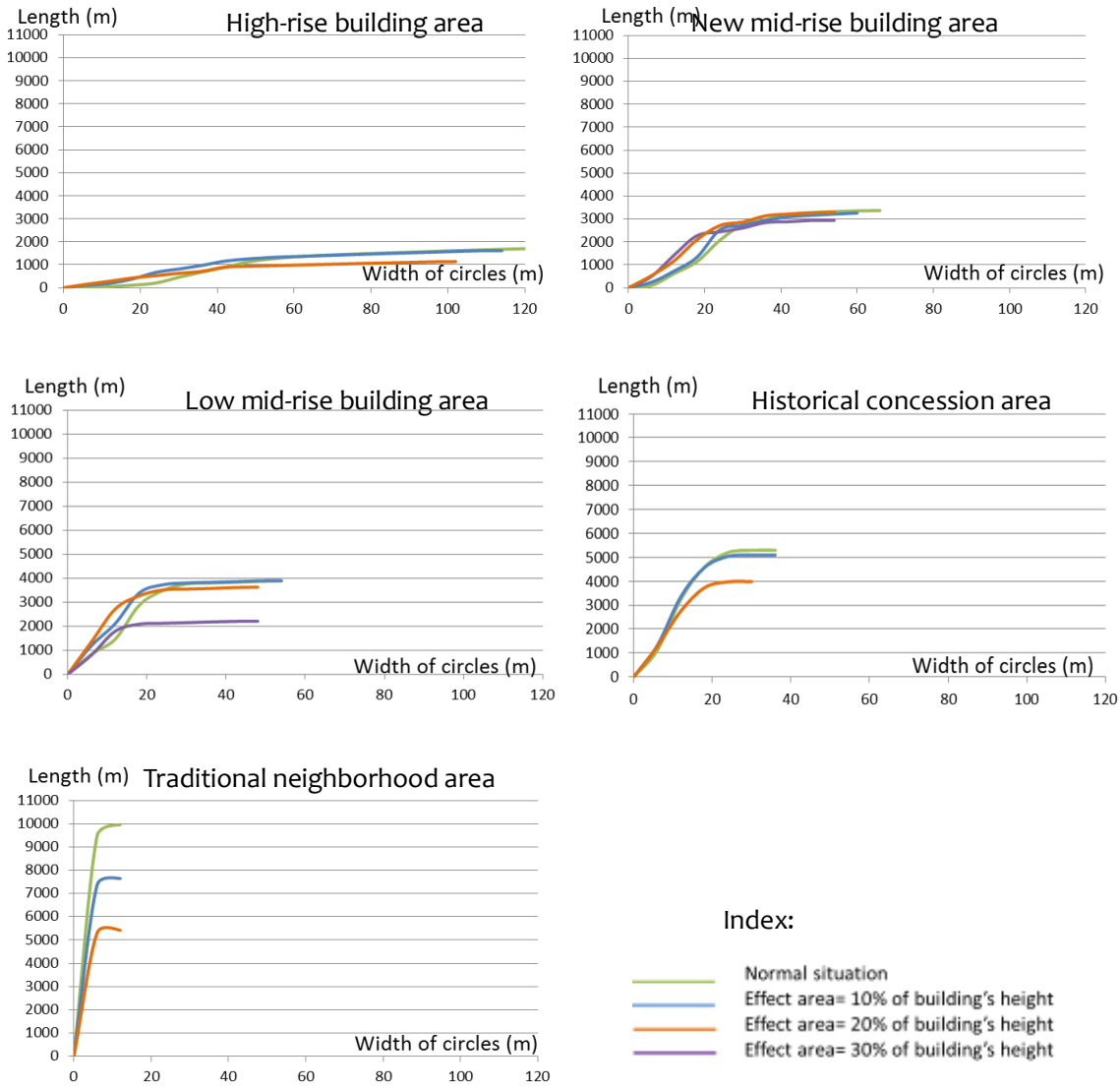


Figure 4-20: Comparison of the accumulative length-width of circulation spaces under various damage situations in different areas

4.4.3 Changing of distance of nearest circulation route

Another way to describe the changes of circulation spaces is using the distance between intersections of circulation spaces and its nearest exit of site. The intersection of circulation spaces is defined as the centers of circle which connect with 3 objects. General, the number of intersection reduce and the length between intersections and nearest exits increase.[5]

In the HB area, the number of intersections drops half when the normal situation shifts to damage level 2. In the NM area, 1/3 of intersections disappeared under damage

[5] Appendix 7 Auto CAD programming 3 – Detection of nearest route between intersections and nearest exit

level 3 as well as the length of nearest route between intersections to exits grows.

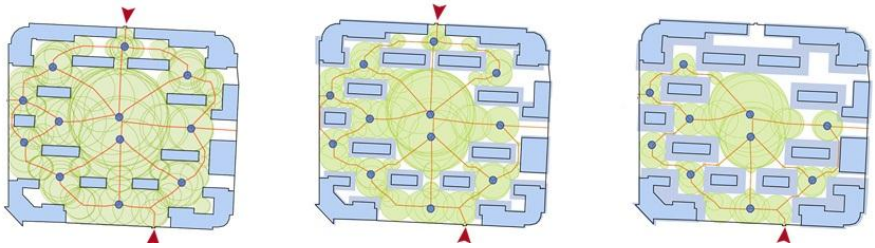


Figure 4-21: Changes of intersections under different damage situation in High-rise building

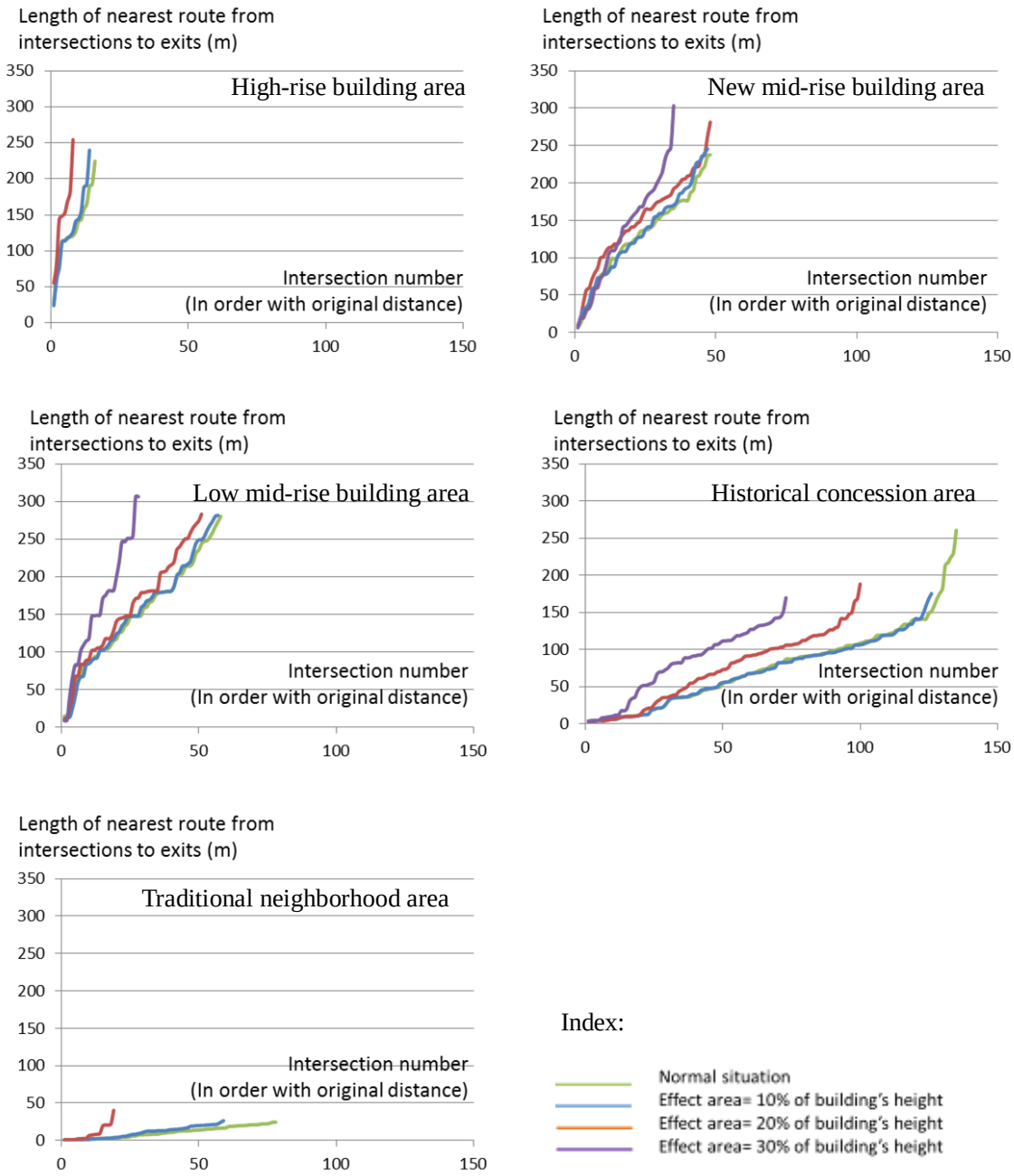


Figure 4-22: Section of usable spaces

OM area shows similar pattern with the previous one, however the reduction of intersection numbers is more than 60%. In the TN area, only 20% of intersections are left when the damage level is set as 2.

TC area presents a different tendency compare with the other areas. The length between intersections and exits reduces when the damage level rises, that is because of some deep location was shut down because of the debris covers the original circulation routes.

4.4.4 Changes in the usable spaces in a residential area

In residential areas, open spaces is to support evacuation, temporary staying, rescue, and transportation. To facilitate specific functions of disaster prevention, circulation spaces, which exceed a certain width and are located in an available circulation route under the damage situation, are defined as usable spaces. Usable space may indicate the vulnerabilities in a target site through a numerical description.

As an essential part of rescue, fire engine access is crucial to extinguish a fire and rescue trapped people. According to the Code for Planning Design of Urban Residential Areas of China (China Architecture & Building Press 2002), the minimum fire passage is 4 m, and a 5 m distance between fire passage and exterior walls of a high-rise building is recommended. However, open spaces are also used for short-term activities and temporary staying, collection or distribution of emergency supplies, etc. Some of these activities require more space than the fire truck passage (Mifune and Hiroko 1997). Therefore, two conditions are set as standards of usable spaces in the current research.

4m: Smallest width for a fire engine

8m: Width for most activities

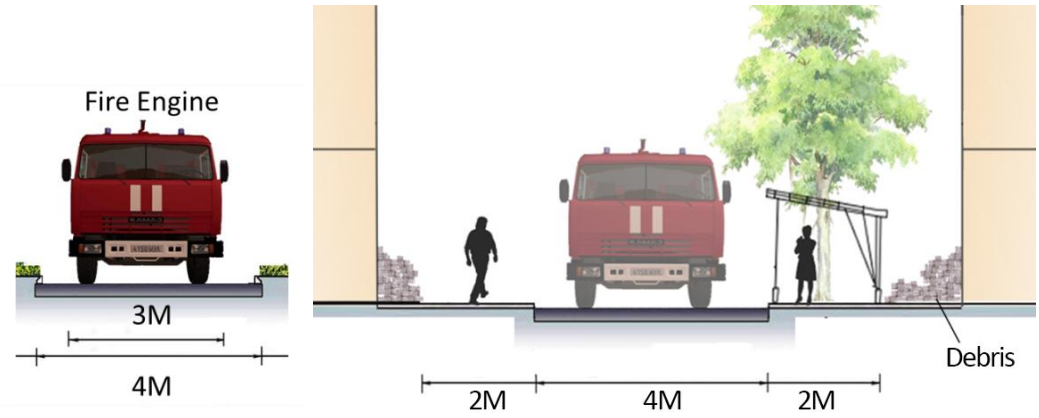


Figure 4-23: Section of usable spaces

We analyzed the usable space in the five types of areas for different damage situations. The comparison of usable spaces under different damage levels shows distinct features (Fig.

4-24) where the green, blue, red, and purple lines indicate the normal situation, damage level 1, damage level 2, and damage level 3, respectively. The horizontal axis denotes the width, while the vertical axis shows the ratio of usable spaces compared to the total circulation spaces in the normal situation.

In the high-rise building area, over 95% of circulation space is suitable for usable space. However, the amount of usable space with widths of 4 m and 8 m drops to approximately 70% and 45% of usable area under damage levels 1 and 2, respectively (Fig. 4-24).

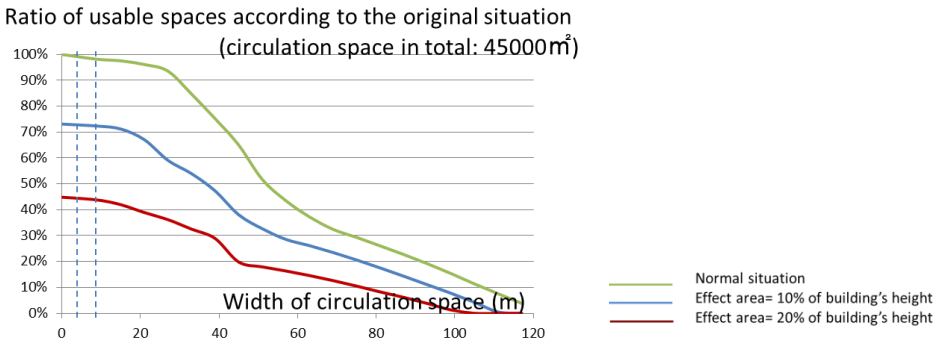


Figure 4-24: Changes in the usable spaces of the high-rise building area

The new mid-rise building area possesses a high ratio of usable space in the normal situation. The tendencies of usable spaces with widths of 4 m and 8 m are similar, and they gradually decrease by 40% for damage level 3 (Fig. 4-26).

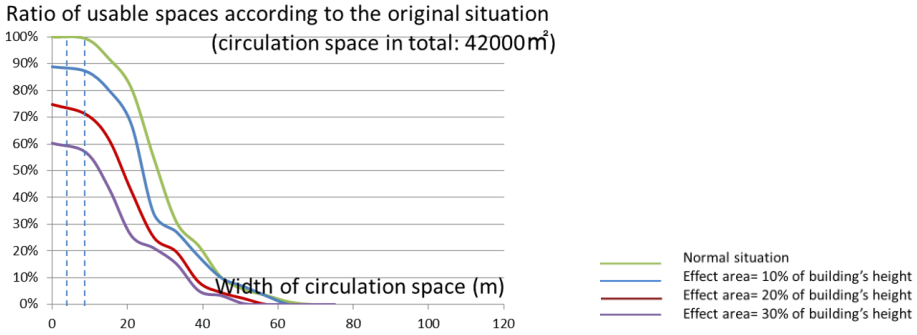


Figure 4-25: Changes in the usable spaces of the new mid-rise building area

In the old mid-rise building area, the total occupied area of circulation spaces is relatively low among all five areas (33000 m^2) (Fig. 4-27). Usable space with a width of 4 m drops from 96% of the total circulation space to 80%, 63%, and 38% from normal situation up to damage level 3, whereas the 8-m wide usable space decreases from 92% of the circulation space to 75%, 56% and 32%, respectively. The decline of usable space with a width of 8 m shows a more distinct variation.

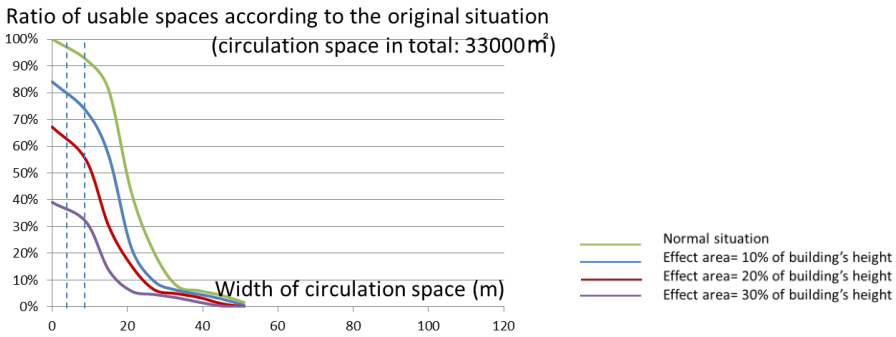


Figure 4-26: Changes in the usable spaces of the old mid-rise building area

The historical concession area shows a sharp decrease in circulation space wider than 8 m. For widths of 4 to 8 m under normal conditions, the decrease is only about 10% for damage level 1 and about 30% for damage level 2 (Fig. 4-28).

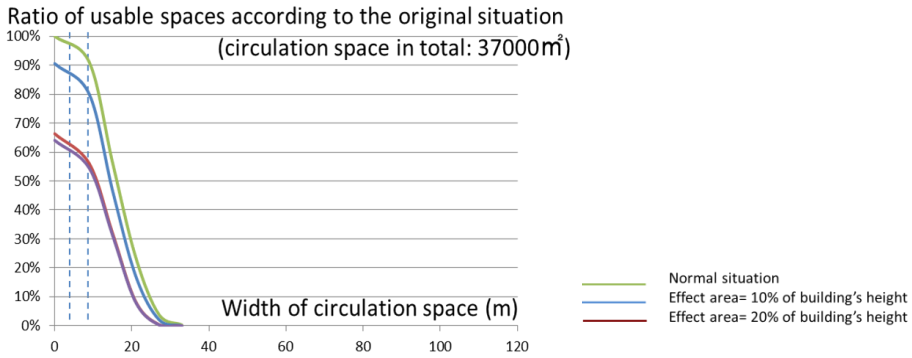


Figure 4-27: Changes in the usable spaces of the historical concession area

Even the traditional neighborhood has a circulation route around 10000 m and the lowest occupied area (31000 m). However, under normal conditions, 60% of the routes have a width of 4 m, but are reduced to 20% in damage level 2. Usable spaces wider than 8 m are very limited in all situations, indicating that access for emergency vehicles (e.g., fire engines) is nearly impossible (Fig. 4-29). Thus, it is hard to facilitate the functions of rescue

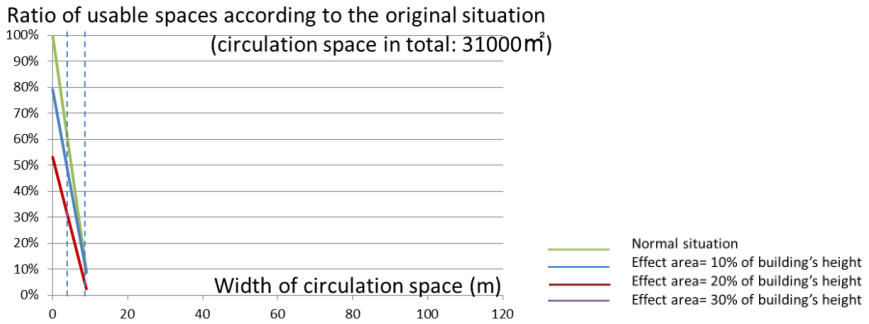


Figure 4-28: Changes in the usable spaces of the Traditional neighborhood area

and emergency goods supply. (No circulation under damage level 3 due to both of the exits lose efficacy)

The new mid-rise building area has best performance with most abundant usable space, while the old mid-rise building and historical concession areas are the most resistant to change. Taking the observations of the site environments into consideration, usable spaces may be curtailed due to illegal parking and sanitary issues in mid-rise building areas. At the same time, the grim outlook causes concerns about the vulnerability of the traditional neighborhood (Fig. 4-28).

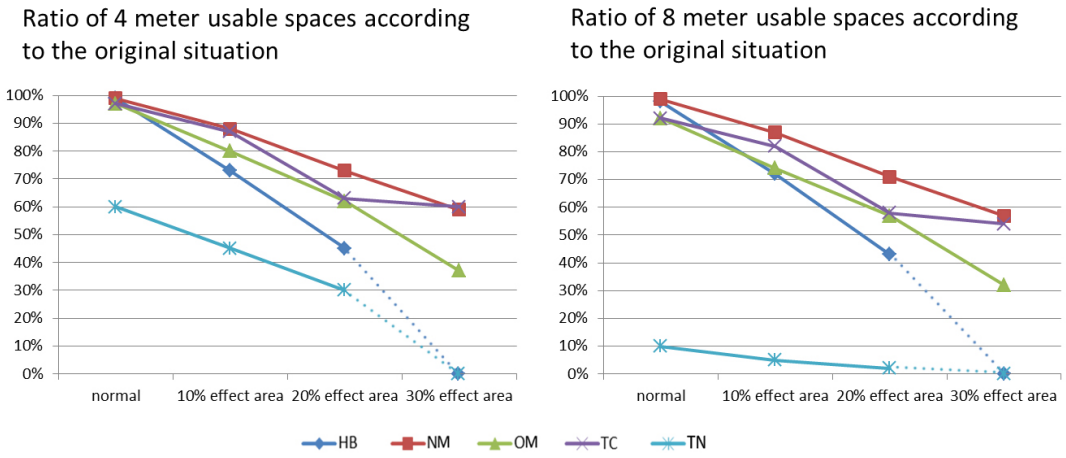


Figure 4-29: Comparison between usable spaces in different areas

4.5 Conclusion

The physical characteristics of residential sites affect the circulation for different levels of damage. These changes can be interpreted through numerical analysis via the Auto CAD program. Analyses of the accumulative length of circulation spaces and usable spaces can describe and evaluate the performance of residential environments according to the damage situation. In conjunction with survey observations, the vulnerabilities on the physical environment are clarified.

Chapter 5

Identification and modifications of constrains of activities along circulation spaces

5 dentification and modifications of constraints of activities along circulation spaces

Lots of activities have been testified to generate since an earthquake happens. The capability of those activities is significant to describe the earthquake-resistance performance. The typical activities happen in the circulation spaces of residential superblocks are various: Evacuation right after the shaking started; A temorary staying in outdoor spaces for the fear of aftershocks from the first several hours till days. Rescue, ambulance and truck transportations in the crucial 72 hours; And the supplement of emergency goods is required in a longer time. An estimation on the constraaints of those activites follow the time sequence is useful for the environment evaluation.

5.1 Estimated evacuation effects

Evacuation is one of the most important function that circulation spaces is expected to facilitate, evacuation efficiency is one of the most straightly value to judge the vulnerabilities of residential environment. The amount of circulation spaces and its spatial organization reflect on different capability for evacuees. Accompany with the shifts of circulation spaces under damage situation, the evacuation efficiency is changing in accordance with the size of population. Using the circulation spaces data and demographical data, we can make the estimations on evacuation effects under different damage situation.

5.1.1 Demographical data

The number of residents is very important in evaluating earthquake disaster prevention, and it is an essential element to access evacuation efficiency. The number of residents was acquired through a statistical inquiry from the local government and calculations based on

statistical parameters.

In the city of Tianjin, the average number of residents in one unit of an apartment is 2.9-3.2 people (Tianjin Municipal Bureau of Statistics 2011). Using this data, the number of residents in high-rise and mid-rise buildings was determined. In the concession area and traditional neighborhood, the number of residents was determined using the community resident number (Office of Heping District, Tianjin n.d.)and building occupancy ratio of the area. The number of residents in each building and the number of people using each entrances of building is counted

Table 4-1: Number of residents in chosen site

Type of area	Occupied area (Ha)	Number of residents	Data resources
HB area	8.37	7600	Number of apartment * Average population density of each apartment
NM area	8.16	2818	
OM area	7.23	4160	
TC area	8.31	2730	Population of community * Ratio of building occupied area of community
TN area	9.91	6920(346)	

[6]

5.1.2 Population movement during evacuation

The evacuees' flow starts from each entrance of buildings, ends up the exit of chosen site. One site may have more than one entrance. The route is defined as a shortest path from the entrances of building to the nearest site exit. The evacuation efficiency (how many people get out/left in chosen site per second) is accounted of all exits of chosen site. The evacuation process is composed by stage 1: travel from apartment door to building exit and stage 2: from building exit to the site entrance.

We assume people get out from building in a constant speed. When the building exit is wider than the stairs, we set the building flow capability by stair width. In contrary, the flow capability will be set by door width. In our chosen areas of HB, NM, OM and TC, we choose the stair of 1.2 meter to calculate the accessibility. The speed of walking in stairs is 0.6m/s, 1.3 people can pass each one meter stair in one second in average(the walking coefficient stair is set as 1.3p/m*s (Architecture Institute of Japan 2001)) Therefore 8 meter length of stairway in each floor will take evacuee approximately 13 seconds in the normal residential buildings. There are 1.56 people get out from each building entrance per second.

In the OT area, the residential buildings have single layer. The floor capacity is

[6] Appendix 3 List of number of residents in each building

accounted by the width of door. Walking coefficient through a 90cm door is taken as 1.5p/m*s. Therefore, 1.35 people can get out from each building entrance for each second.

Table 4-2: Evacuation time of stage 1 in different types of residential area

	HB	NM	OM	TC	OT
FLOORS	24	6	5	3	1
TIMES FOR STAGE 1	310	65	52	40	0

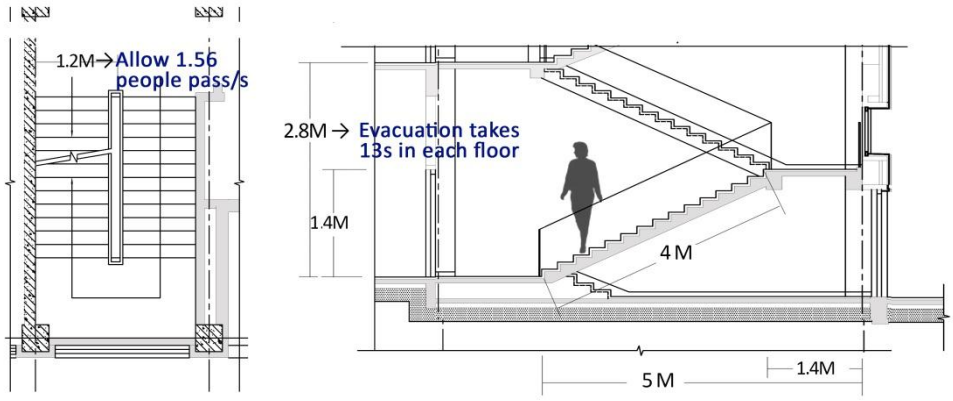


Figure 5-1: Section of stairs used for evacuation time calculation

Speed in stairs: 0.6m/s Width of stair: 1.2m Walking coefficient stair: 1.3p/m*s

In each circulation route, the stream flow together after evacuees get out from their building entrances, when the number of people exceeds the capacitance of a particular route (which is decided by the coefficient of walking and width of route), the congestion happens and the crowds may delayed. We can calculate the route capability by using the coefficient of waling of 1.4 p/ m*s (Architecture Institute of Japan 2001)**.** Under the walking velocity of 1.4m/s, the evacuation time during certain route is calculated. Consequently the time of delays can be counted in accordance under the biggest capability of certain route. [7]

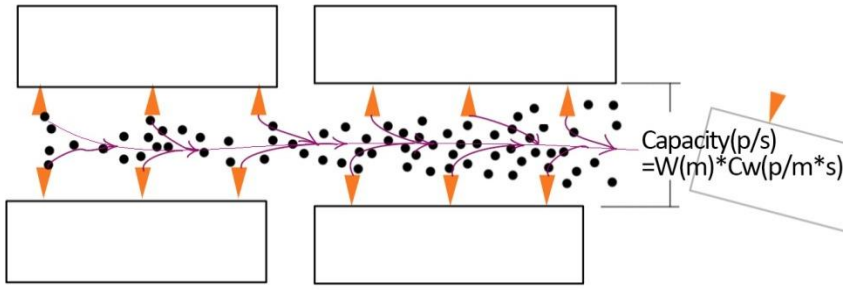


Figure 5-2: Evacuation flow joint at intersection and getting delay

Velocity of walking: 1.4m/s Coefficient of walking: 1.4p/m*s

[7] Appendix 9 Calculation programming of evacuation time calculation 1 – in single route

When more than one path flows together, when the number of people exceeds the capacitance of a main route, the congestion happens again. The evacuation time is calculated again by the positions of each intersection and the capacitance of the main route using the same strategy as before.[8]

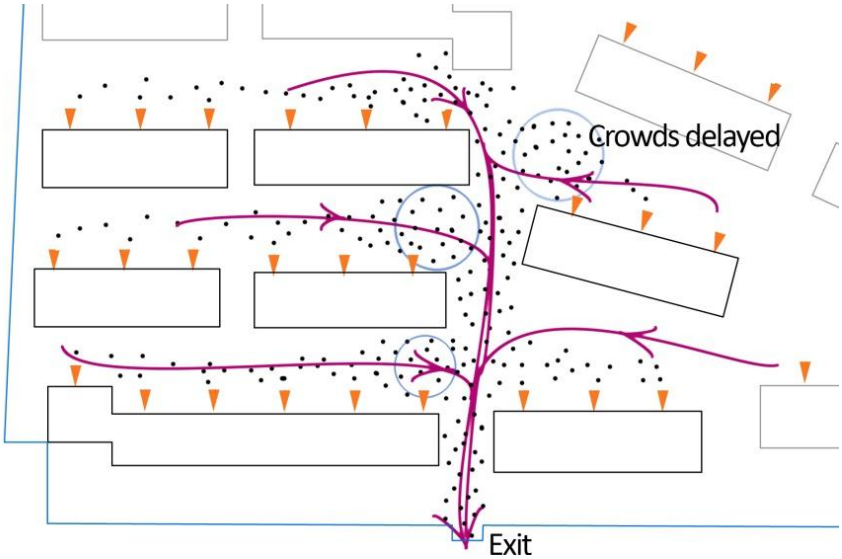
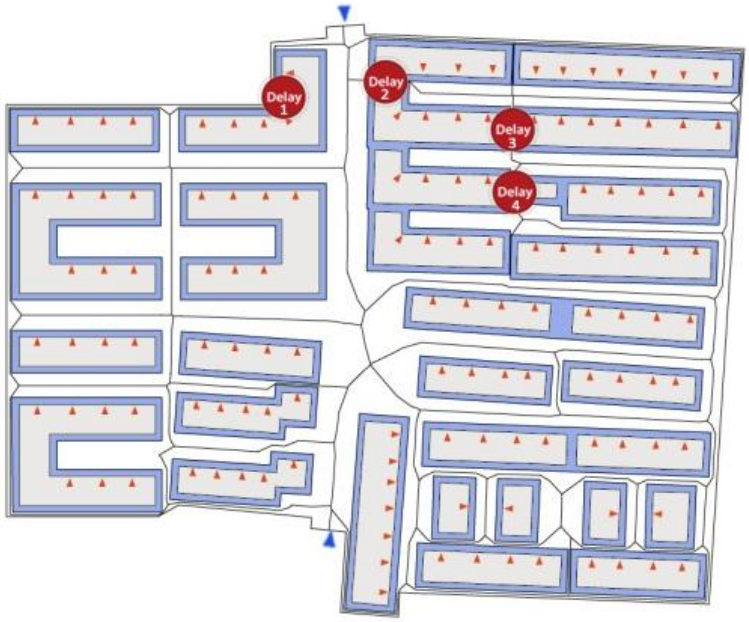


Figure 5-3: Evacuation flow joint at main path may cause delay

When the congestion comes, the flow of evacuee changes. In some cases, the total evacuation time in certain circulation route extents (Figure 5-4 (A)). In some other cases, the flow of evacuee changes but the final evacuation time remains. (Figure 5-4 (B)) [9]



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[8] Appendix 4 Details of delay of population movement
[9] Appendix 10 Calculation programming of evacuation time calculation 2 – flow of routes

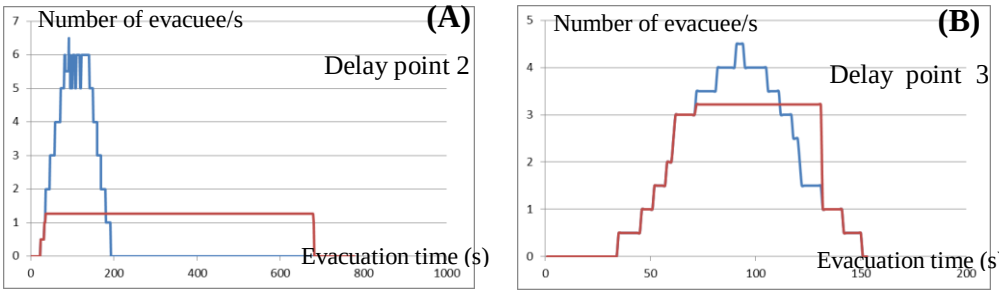


Figure 5-4: Changing of evacuation time when congestion happens in old-middle rise building area under damage level 2

5.1.3 Assessment of evacuation efficiency in different damage situation

We use the number of left people in the residential site by time sequence to represent the evacuation efficiency. As figure 5-4 shows, the vertical axis indicates the number of people left inside the residential site, and the horizontal axis shows the evacuation time. In all areas, the changes up to damage level 1 (effecting area is 10% of building's height) are very limited. Once the effecting area exceeds 10% building's height all the areas show different tendency.

High-rise building area has the biggest number of residents of 8000, which is at least double than other 3 areas. The evacuation efficiency is hard to find when the effecting area is 10% of building's height. But near 3000 people can't find an evacuation route while the damage area reaches 20% of building's height. The evacuation situation under the damage level 3 is not included due to the circulation route to both exits are shut.

The New middle-rise building area has very good evacuation effects since it has the fastest evacuation speed under all situations. And no evacuees will be left up to damage level 3.

In the Old middle-rise building area, evacuation appears difficulties when the damage situation exceeds level 2. Evacuation time grows 4 times (from 250s to 1000s) when the effecting area is set as 20% of building's height, and 1/3 of people will be left inside under damage level 3.

The changes of evacuation efficiency under different damage situation in traditional concession area is quite small, this area has the smallest population density among all samples, 76 people are left when damage level 3 happens while the evacuation time will be doubled than the normal situation.

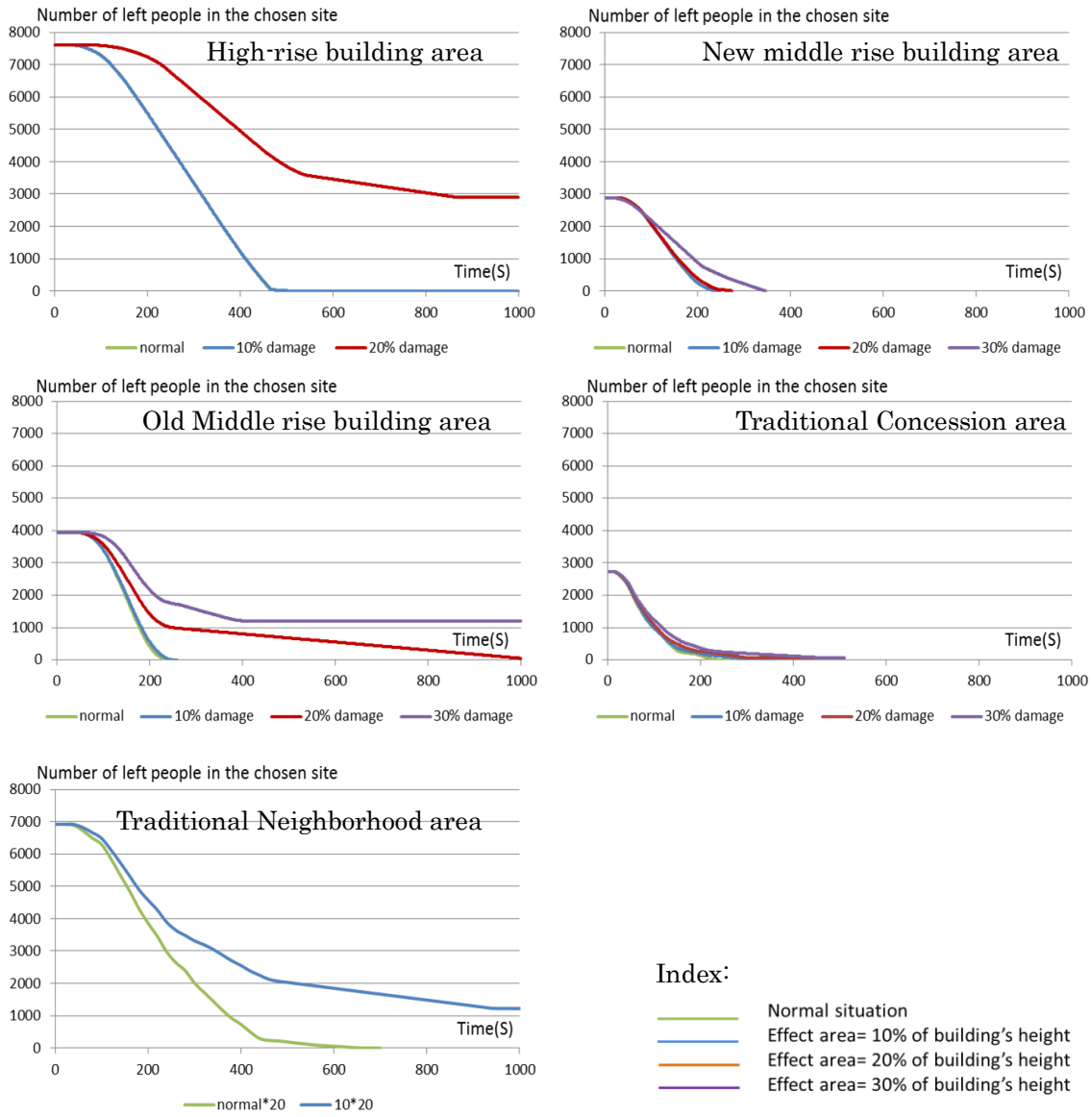


Figure 5-4: Comparison of the number of left people in residential sites under different damage situation

5.2 Usable spaces network (Via a visualized map)

Besides the spaces used for evacuation, the usable spaces for vehicle access and emergency supplies is considered. The accessible depth of circulation spaces for both pedestrian and vehicle is estimated to show the easiness when accessing a certain area.

We use a visualization method to show the changing of reachable area which is persuadable for illustrating the earthquake vulnerability. The depth of circulation spaces is categorized by each 40 meters (30 seconds walking distance, walking speed = 1.4m/s) starting

from the site exit, represented in eight different colors (area deeper than 340m is shown as the same color with 340 meter) in a visualized map. [10]

5.2.1 Reachable area of pedestrian along circulation route

The spaces wider than 0.6 meter along circulation routes are defined as reachable area of pedestrian (Architecture Institute of Japan 2001). It grievous relates with the practicability of rescue. The depth is measured starting from each exit of site, it changes while the damage level increases. Under different damage situation, either the region or depth of accessible area is changing. In some cases, a bigger debris covered area shut down some shortcut of circulation routes.

For instance, in the Old middle-rise building area, it reflects on the distance increasing between the exits to certain location under damage level 2. And when more circulation routes turn narrower or even close under damage level 3, some of the areas are no more accessible. (Fig. 5-5)

5.2.2 Reachable area of vehicle along circulation route

Vehicle reachable area is important for understanding how the circulation spaces facilitate the fire engine access. It is defined as the spaces wider than 4 meter along circulation route. Same category of each 40 meters is used to represent the space depth in different color through the visualized map. The changes of reachable area for vehicles are more distinct compare with the reachable area for pedestrian. As shown in figure 5-5, the extended of routes can be found since damage level 1, and almost half of the area can't be reached under damage level 3

[10] Appendix 8 Auto CAD programming 3 – Detection of nearest route between intersections and nearest exit

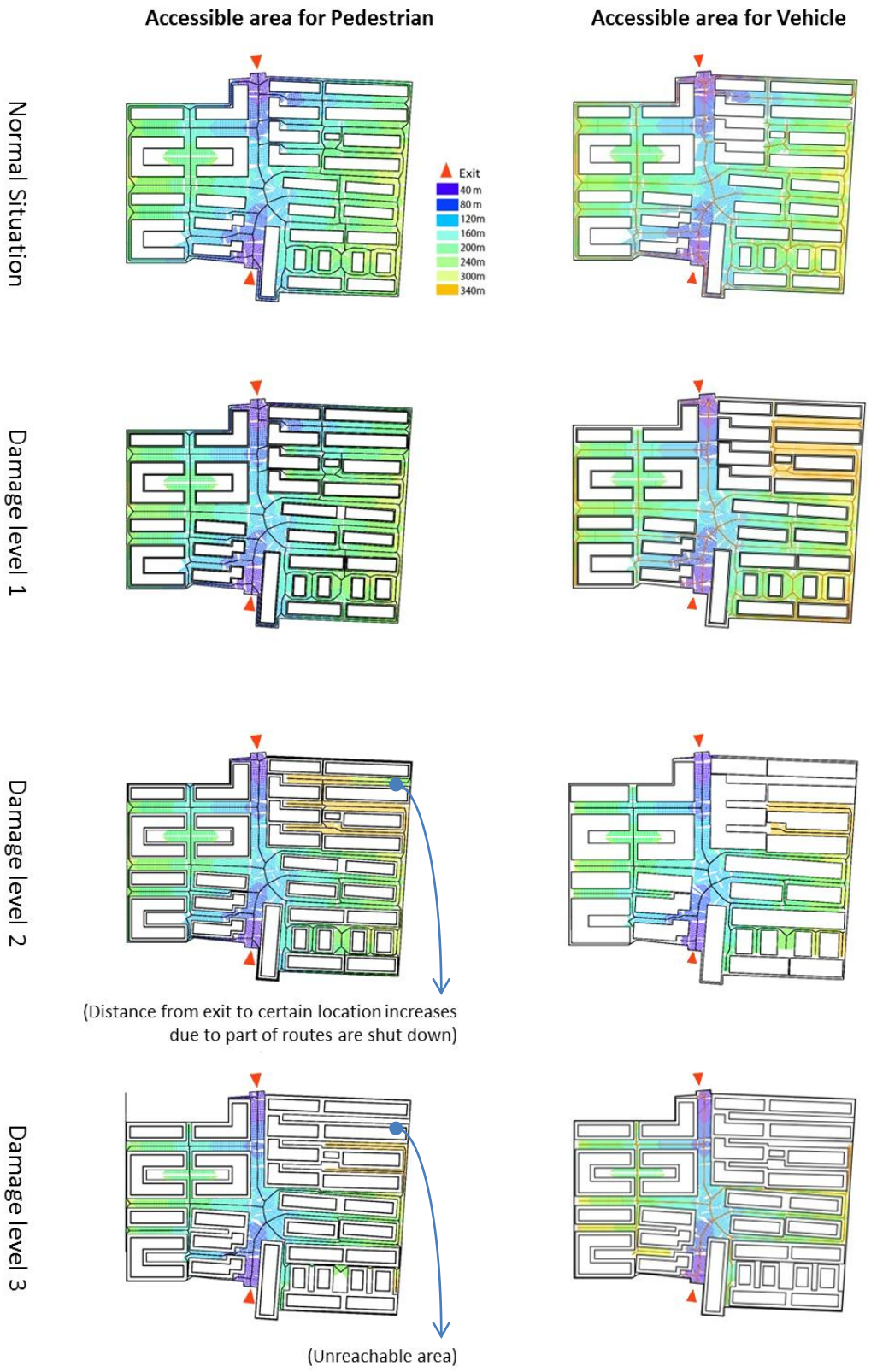


Figure 5-5:
Visualize map of accessible area in Old low-middle rise building area

5.2.3 Connections of usable spaces

The usable spaces are not always connected as a continued space in the residential areas. Some spaces fulfill with width condition are weak connected or isolated with the whole space network, which are not recommended to utilize for certain function of disaster prevention.

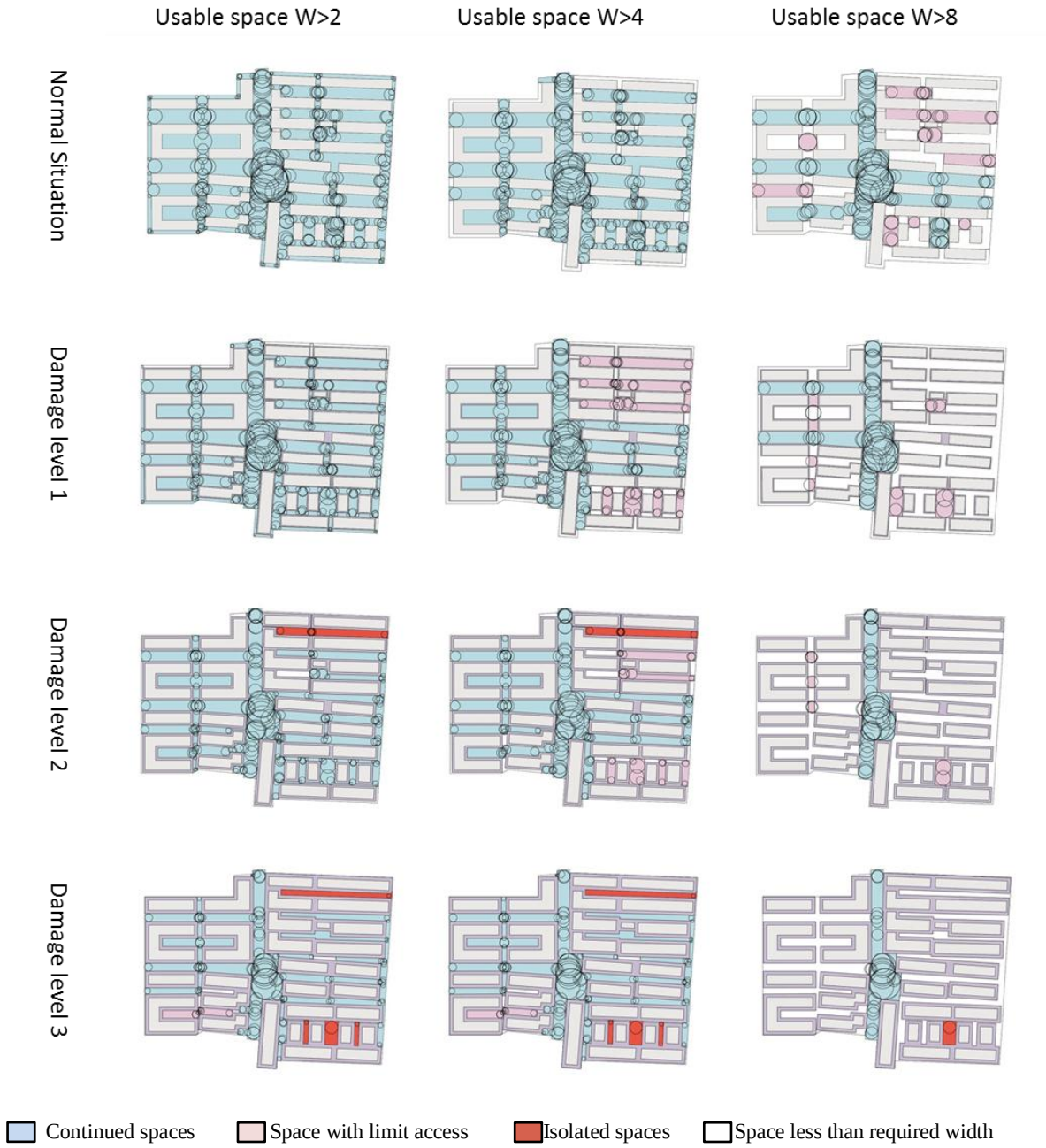


Figure 5-6:
Connection of usable spaces in Old low-middle rise building area

In the above comparison of usable space network of Old Middle-rise building area, all

of the colored area represents the open spaces fitting for certain width requirement(Width=2,4,8 meter). The blue color shows the continued spaces wider than required condition which are deemed to stable for utilization., pink color of Space with limit access indicates the spaces with certain width but which connect with the network by narrower spaces. The red one shows the spaces with certain width isolated from the network.

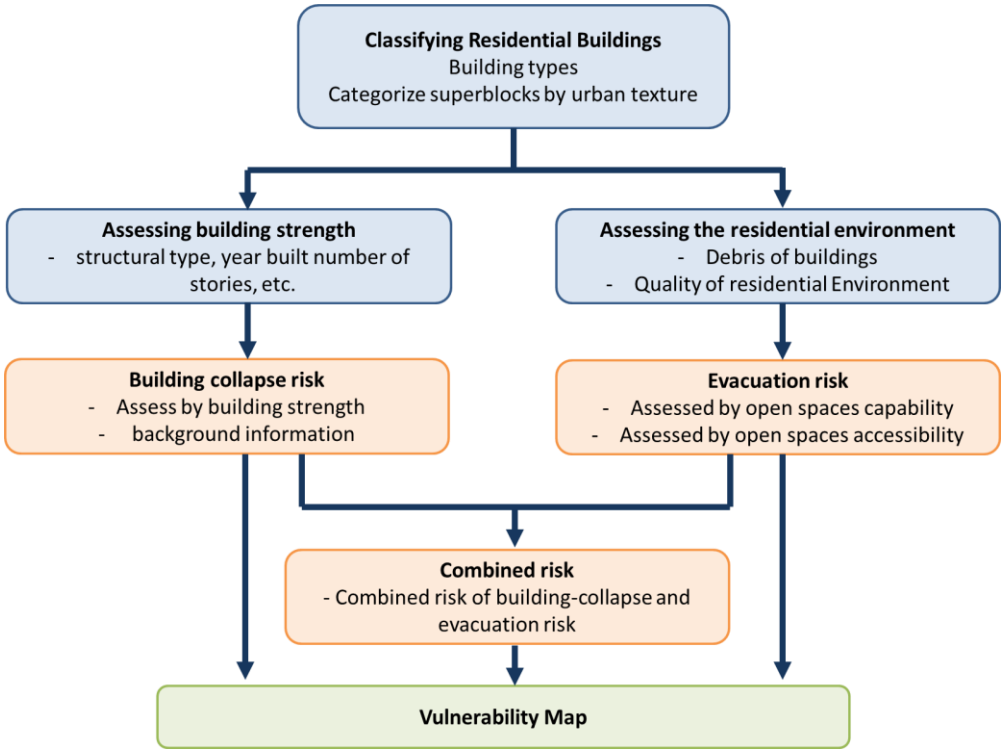
5.3 Improvement proposal for earthquake disaster prevention in residential area

Base on the understanding of the constraints of activities along circulation spaces, as well as the consideration of current situation in Chinese cities, targeted proposals could bring forward to better facilitate for earthquake disaster prevention. The improvements are possible to be addressed from both comprehensive suggestions and implementation counter measures. Different proposals are corresponding to the different phrase of disaster prevention in the urban residential area.

5.3.1 Evaluation system for earthquake vulnerabilities

Followed the experiences of the vulnerability evaluation system in Japan, picking up the most threats items of vulnerabilities in the residential areas towards earthquake disaster, a regional vulnerability map could be constructed based on the physical characteristic of Chinese cities. (Bureau of Urban Development of Tokyo 2013)

Table 5-3: Possible vulnerability evaluation system in residential area of Chinese cities



The risk of building collapse and the risk of evacuation safety are possible to be concerned as the most dominant vulnerabilities of Chinese cities. Which combined evaluation results could be represented in regional vulnerability maps in order to make residence clarify the earthquake vulnerabilities in their living neighborhood.

5.3.2 Means of spatial analysis for evaluation of the improvements in constructed areas

Through the visualization analysis we make clear the accessibility of residential areas alone circulation route. Same method applied to improvement proposals could help us examining and comparing the results of improvement.

1) Improvement of accessibility

For areas with low accessibility, adding exits can directly improve the condition. New exits shorten the nearest distance from intersections of circulation spaces to site exits in

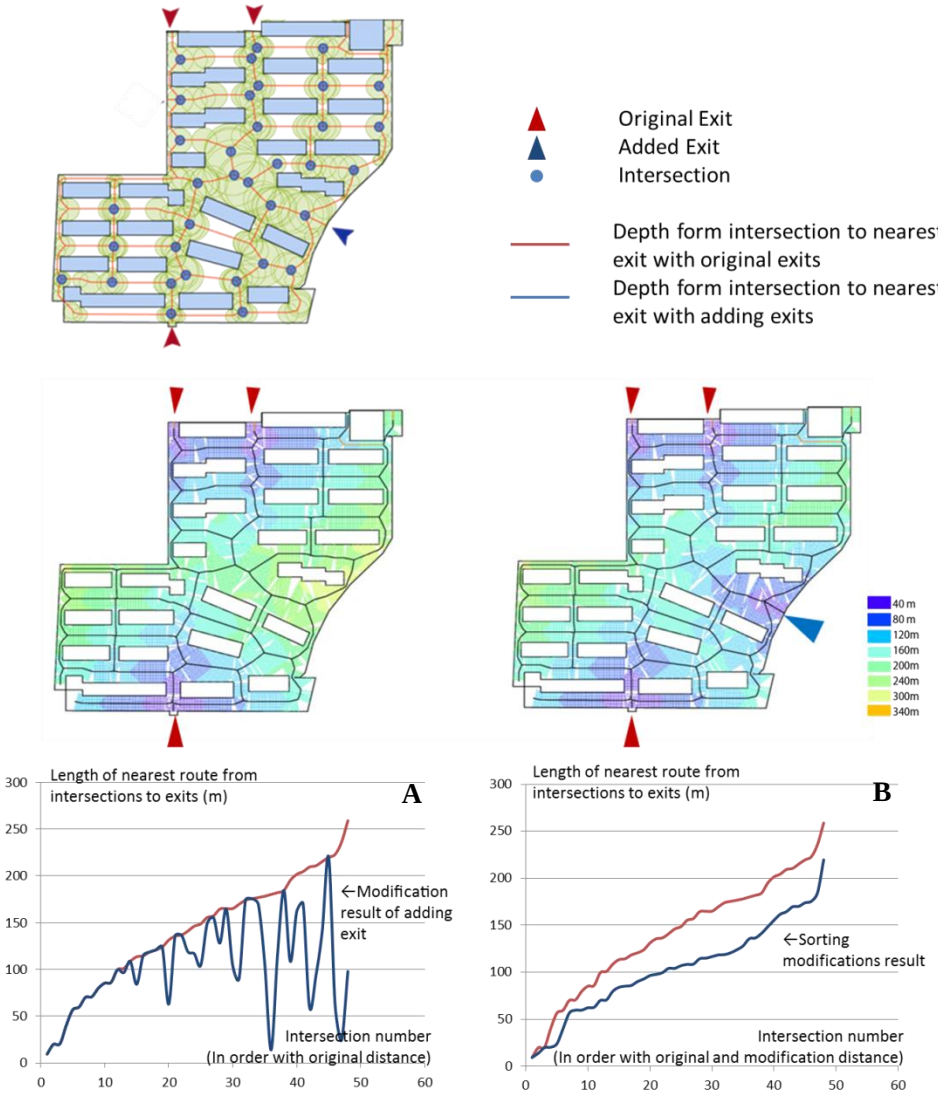


Table 5-7: Shorten of nearest circulation route by adding exit in New Middle-rise building area under normal situation

certain locations and shallow the depth of reachable area.

In the New middle-rise building area, an adding exit in the east of site boundary substantially changed the situation. Figure 5-7-A shows the changing of distance from the same intersection to its nearest exit, the length of route compressed especially the routes originally with long distance. The biggest range of drop is near 200 meter. It reduced approximately 25% of average distance of nearest circulation route between intersections of circulation spaces and site exits under normal situation through sorting the data by distance in Figure 5-7-B.

Even the total number of intersections decline while the route between intersections and its nearest exit is longer with only original exits under damage level 3, adding exit also works. Figure 5-8 shows the effects of adding exit under damage level3, the biggest drop is around 250 meter and around 20% of the distance of nearest circulation route is cut.

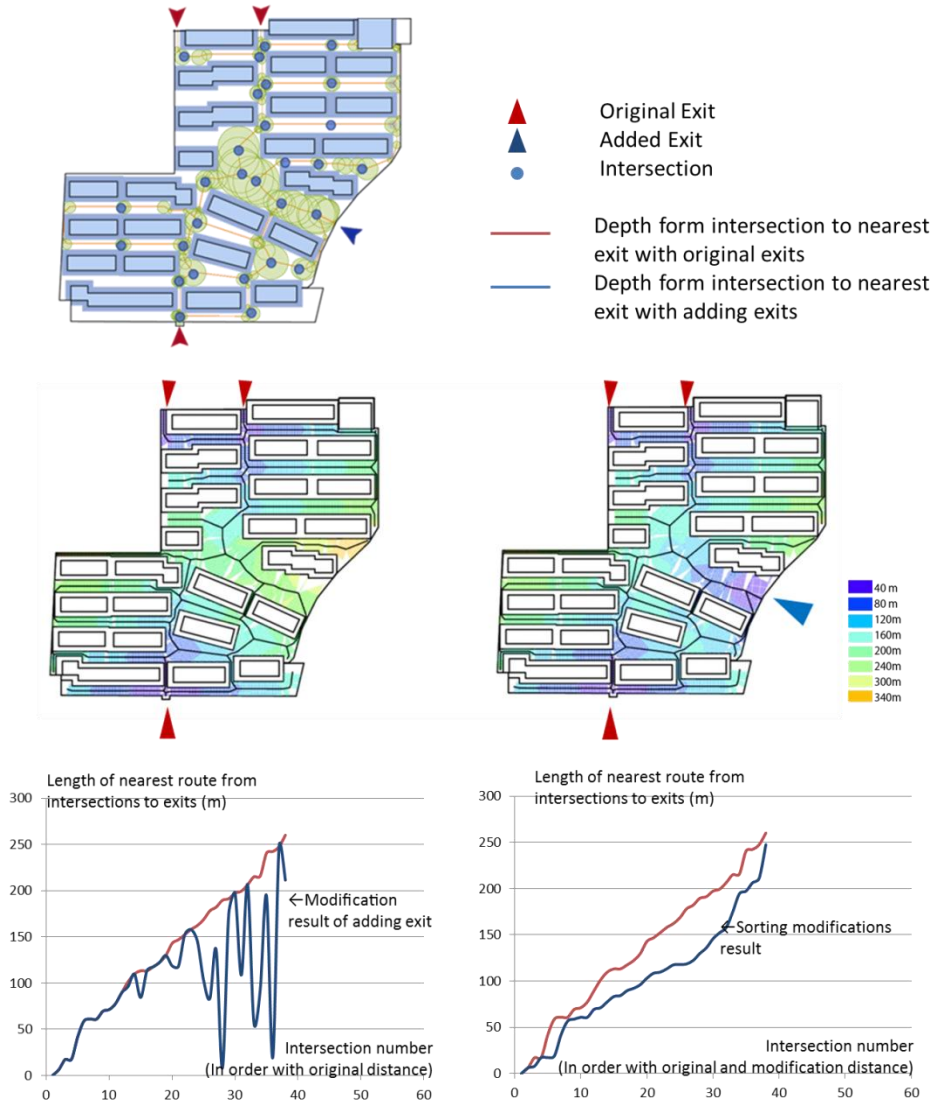


Figure 5-8: Shorten of nearest circulation route by adding exit in New Middle-rise building area under damage level 3

The way to add exits depends on the layout. Figure 5-9 shows the distance from the intersections of circulation spaces and the nearest exit by adding exits at different locations. It decreases the distance, but not all locations have the same impact. In the high-rise building area, add the exit C obviously has better effects than the location of exit A and B. (Fig. 5-9)

This analysis can help us to determine the most effective solution for the number of exits as well as their locations. Adding exits is a feasible way to minimize the number of potential victims while effectively using open spaces. (Ma and Ohno 2013)

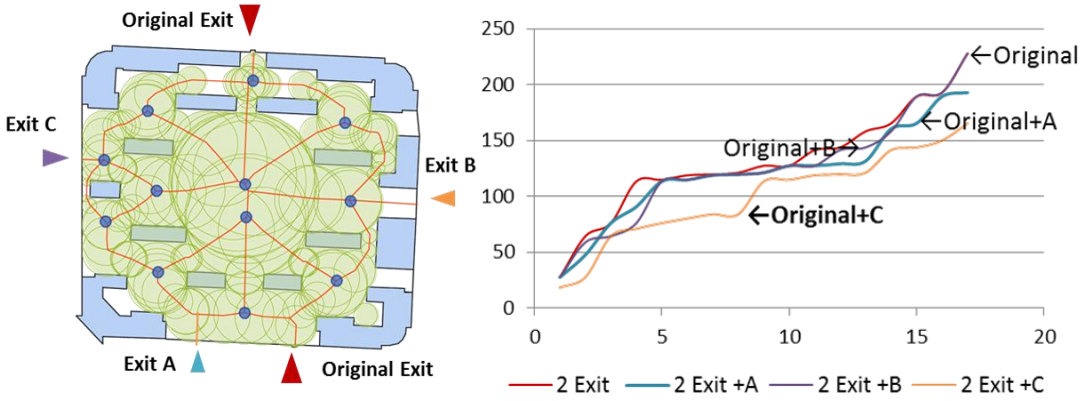


Table 5-9: shortest distance from the intersection and nearest exits by different location In High-rise building area in normal situation

2) Choose open spaces for certain usage

As a combination of the applications of accessibility and usable spaces, optimization can be addressed based on the evaluation and basic information of the target site. The most reachable usable spaces with stable accessibility under different damage situation can be figured out and chose. The capability of which facilitated functions is possible to be estimated. Figure 5-10 shows the reachable area with a more than 4 meter width in High-rise building area, the spaces in middle of site and near the south exit have the most steady accessibility, which could ensure a passage way for fire engine, ambulance even trucks, used for temporary staying and emergency supplies.

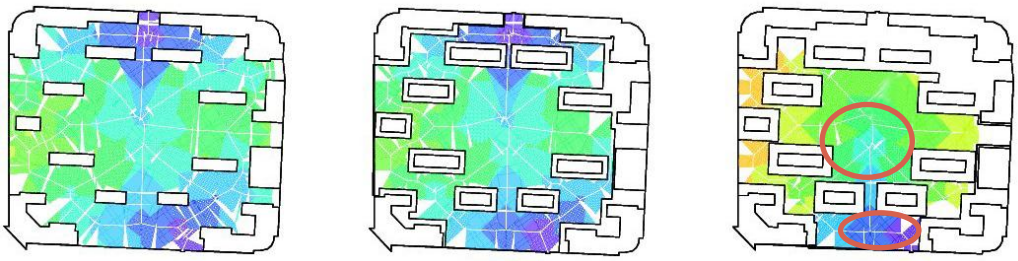


Table 5-10: Chosen of open spaces for goods distribution or temporary staying in High-rise building area

The biggest single open spaces remains 0.95ha (2/3 size of original situation) in the damage level 2, by which we can calculate capacity of certain purpose of utilization.

3) Demolish the illegal buildings and constructions

As figuring out the most stable locations of residential site. The most vulnerable locations are possible to be found: such as the bottle neck route or barrier constructions which depress the capacity of access and make a detour.

Demolishing of illegal constructions, opening up exits on the walls of fences, even remove some buildings which terrible effects the circulation could enhance the accessibility and improve the availability of open space utilization, which is possible to help the constructed area adapt for disaster prevention in an economical way.

Figure 5-11 shows the Changing of accessibility when the walls and fences are removed from Traditional Concession area, by which the area with low accessibility improves a lot.

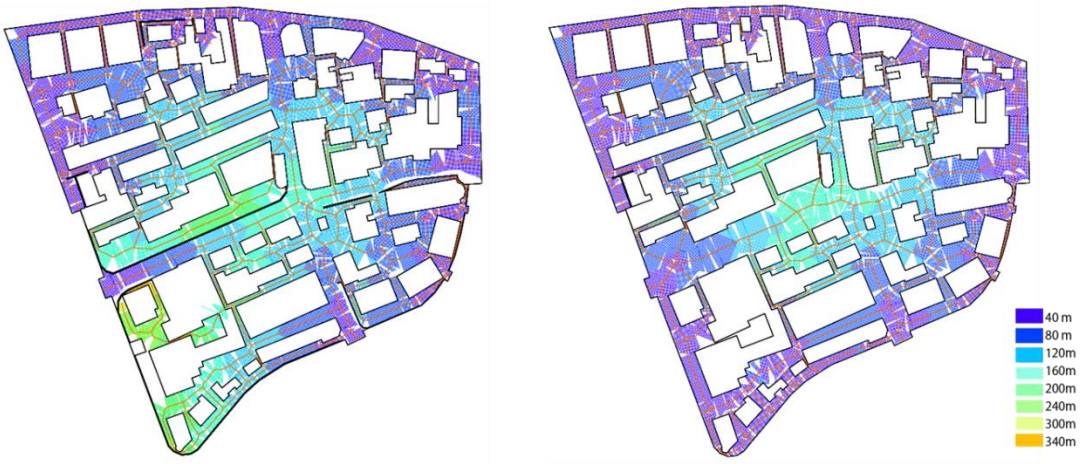


Figure 5-11: Changing of accessibility when the walls and fences are removed In Traditional Concession area

5.3.3 Sustain in future designs

We can also bring forward the improvement proposals into future designs. By the objective evaluation and comparison of analysis, we can adjust the layout of planning from the stage of drawing. The design layout can be amended, tested, and optimized all through the auto CAD programming. It shifts the earthquake disaster prevention to an earlier stage through the evidence based design.

1) Optimization of distance between buildings

The distance between buildings is an important element when discussing the quality of a living environment. Particularly in residential areas, varying the distances between buildings provides spaces with differing characteristics, supporting air flow, natural

sunlight, and diverse activities in our daily life.

The spaces between buildings are designed by sunshine duration and fire prevention standard according to the design code in China (China Architecture & Building Press 2002), the spaces facilitate the disaster prevention are not be attached importance. The distance between buildings are strongly relating with the earthquake disaster prevention by its effects on circulation spaces. An enough distance left by debris covered area plays an essential role for human survival. Hence, adjusting the distance between buildings with the consideration of circulation spaces under different damage situation can be applied (with designed building strength and predicted seismic movement), it may promote safer environment and improve space utilization.

2) Constrain the layout and building shape

Different area have different performance of circulation spaces, it tightly connect with the layout and exit location of the site. Also, some of the building with certain shape, such as: building with ultra-length, multi-angled, or convex in the upper part are more possible to bring in vulnerabilities for circulation. Applying the programming and analysis, testing the layout design, we could make the area without blind side for circulation, layout the facilities and buildings in safer places. We can also create appropriate open spaces with objectives in order to facilitate disaster prevention of certain functions. The direction of building entrances also can be tested by this analysis in order to balance the evacuee distributions.

Those evidence based design are provided for sustainable development with higher pertinence, it is flexible to integrate the demands for different geographical feature and building type selections.

5.4 Conclusion

The identification of constraints of activities along circulation spaces helped to understand the earthquake vulnerability and space utilization through intuitive ways. The earthquake impacts on residential environment which constrain the evacuation, accessibility and space utilizations are distinguished. The improvement proposals could modify constrains through both comprehensive and implementation approaches. Vulnerability evaluation system is suggested as the primal stage of disaster prevention. Measures to improve the accessibility (adding exit in the best location), choose usable spaces and demolish certain constructions are proposed for ameliorating the environment in built up area. Proposals facilitating for future designs are also addressed in terms of the evidence based design.

Chapter 6

Conclusion

6

6. Conclusion

China is a seismically active country, and in the last few decades the threat of a natural disaster to the living environment has grown. Earthquake has resulted in many fatalities and extensive damage, disaster prevention and prevention has been major concerns. In accordance with the characteristic of earthquake damage in China and the physical characteristics of China's cities, creating a proper open space system is a very effective approach for earthquake disaster prevention in the residential areas of Chinese cities.

In the chapter 1 of introduction, we denoted the utilization of open spaces in the post disaster period is comprehensive distributed in lots of countries. Cases can be found in the US, Japan, Chile and other earthquake prone countries. Residents prefer to use open spaces near their houses right after a disaster which greatly contributed to the physical resilience. The open spaces provided to evacuation sites, disaster relief, life support, a lifeline system, and temporary housing distribution has been proved to facilitate disaster prevention efficiently.

Through the analysis in Chapter 2 " Requirements of an open space for earthquake disaster prevention in residential environments in Chinese cities". We found in the urban area of China, the urban elements can be classified into five categories based on their scale: buildings, neighborhoods, communities, superblocks, and city. Although the avenues which divide urban area into superblocks are regarded as safe evacuation routes, they may not be directly accessible due to difficulties within the superblocks (e.g., a natural barrier or a human-caused barrier). Thus, the open spaces inside superblocks are very important to provide direct evacuation routes and spaces for short-term activities, to facilitate disaster prevention.

In the chapter 3 " Concept of circulation space to evaluate earthquake vulnerability and its detection method", the concept of "circulation space" is developed which identifies the continuous open spaces between buildings, creates a passage that facilitates the free movement of people in a particular area. It is used as a criterion to evaluate earthquake vulnerabilities in the different areas. Additionally, an AutoCAD programming application is provided to assess open spaces between buildings and automatically output numerical data which is useful for various space analyses under different scenarios. It was applied to examine vulnerabilities against an earthquake in a residential environment and provide numerical measures for an objective evaluation.

In Chapter 4 “Analysis of physical characteristics of circulation space for earthquake disaster prevention in superblocks”, observations of outdoor spatial arrangements and environmental details from a field survey are conducted in different types of residential areas in city of Tianjin, China. 5 types of residential area are applied for programming analysis (High-rise building area, New Middle-rise building area, Old Middle-rise building area, Traditional Concession area, Traditional Neighborhood area). In different layout of residential site, it has various performances towards earthquake disaster. The physical characteristics of residential sites affect the circulation for different levels of damage. Analyses on the changing of circulation spaces and usable spaces are confirmed possible to describe and evaluate the performance of residential environments according to the damage situation. In conjunction with survey observations, the vulnerabilities on the physical environment are clarified. In the real case evaluation of Tianjin, five types of residential area shows different characteristic towards earthquake disaster. Middle-rise building areas possess the most stable situation against earthquake while the traditional neighborhood faces extremely dangers.

In Chapter 5 “Identification and modifications of constraints of activities along circulation spaces”, through the identification of constraints of activities along circulation spaces, it interpreted the earthquake vulnerability into the effects on post disaster activities, the earthquake vulnerability and space utilization are read through intuitively. The constraints of evacuation, accessibility and space utilizations are distinguished. Improvement proposals modified vulnerabilities through both comprehensive suggestion and implementation approaches area brought forward targeted to different stage of disaster prevention. The vulnerability evaluation system is suggested as the primal stage of disaster prevention. Measures to improve the accessibility, choose usable spaces and demolish certain constructions are proposed for ameliorating the environment in built up area. Proposals facilitating for future designs are also addressed in terms of the evidence based design.

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Appendix

1. Measurements of open spaces

Proximity measures

There are several simple and intuitive ways to calculate proximity to target points to measure the accessibility of open spaces.. These include ‘minimizing travel cost method’, ‘covering objectives method’, and ‘minimum distance method’. (Talen 2003)

Minimizing travel cost method calculates the average distance from the origin to desired destinations; Covering objectives method counts the number of desired destinations in a certain limit of distance from the origin; Minimum distance method measures the distance from the origin to the nearest destination. While it seems that all of these measures provide reasonable measures about proximity, they capture different aspects of reality. The accessibility pattern changes substantially according to which measure was used.

Gravity models

Gravity models are used in various social sciences to predict and describe certain behaviors that simulate gravitational interaction as described in law of gravity. The gravity model assumes that the trips produced at an origin and attracted to a destination are directly proportional to the total trip productions at the origin and the total attractions at the destination (Oregon State University n.d.). It based on two types of variables, attraction factors and friction factors. Atraction factors are defined by the characteristics of the destination, such as the number of employees or size of facilities, which can provide more satisfaction to the users; Friction factors are based mostly on distance and cost to reach the destination. Gravity model has been extensively used to model accessibility to target destinations. Knox (1978) who used gravity-based model for medical care service accessibility. Recently, there have been several attempts to integrate accessibility measures among different types of facilities and different modes of mobility, by using gravity models. Tsou, Hung, and Chang (2005) develop indices which reflect accessibility to parks, education facilities, community facilities and traditional markets at both aggregated and disaggregated levels.

Utility-Based Model and Activity Based Model

This is based on random utility theory, Random utility theory models an agent’s preferences on alternatives by drawing a real-valued score on each alternative from a parameterized distribution, and then ranking the alternatives according to scores

(Soufiani, David C. Parkes and Lirong Xia 2012). This model can illustrate the changes of accessibility according to different personal and policy choices with monetary values.

Hedonic pricing model

Certain environmental services often influence the market prices. The Hedonic pricing method is often brought into play in order to assess the economic values of such services. This method finds its application to reveal the effect of environmental attributes in changes in the local real estate pricing. It is frequently used for estimating costs related to: The overall quality of the environmental amenities which include aesthetic sights and closeness to recreational sites such as parks, beaches, open spaces, etc. (KING 2000)

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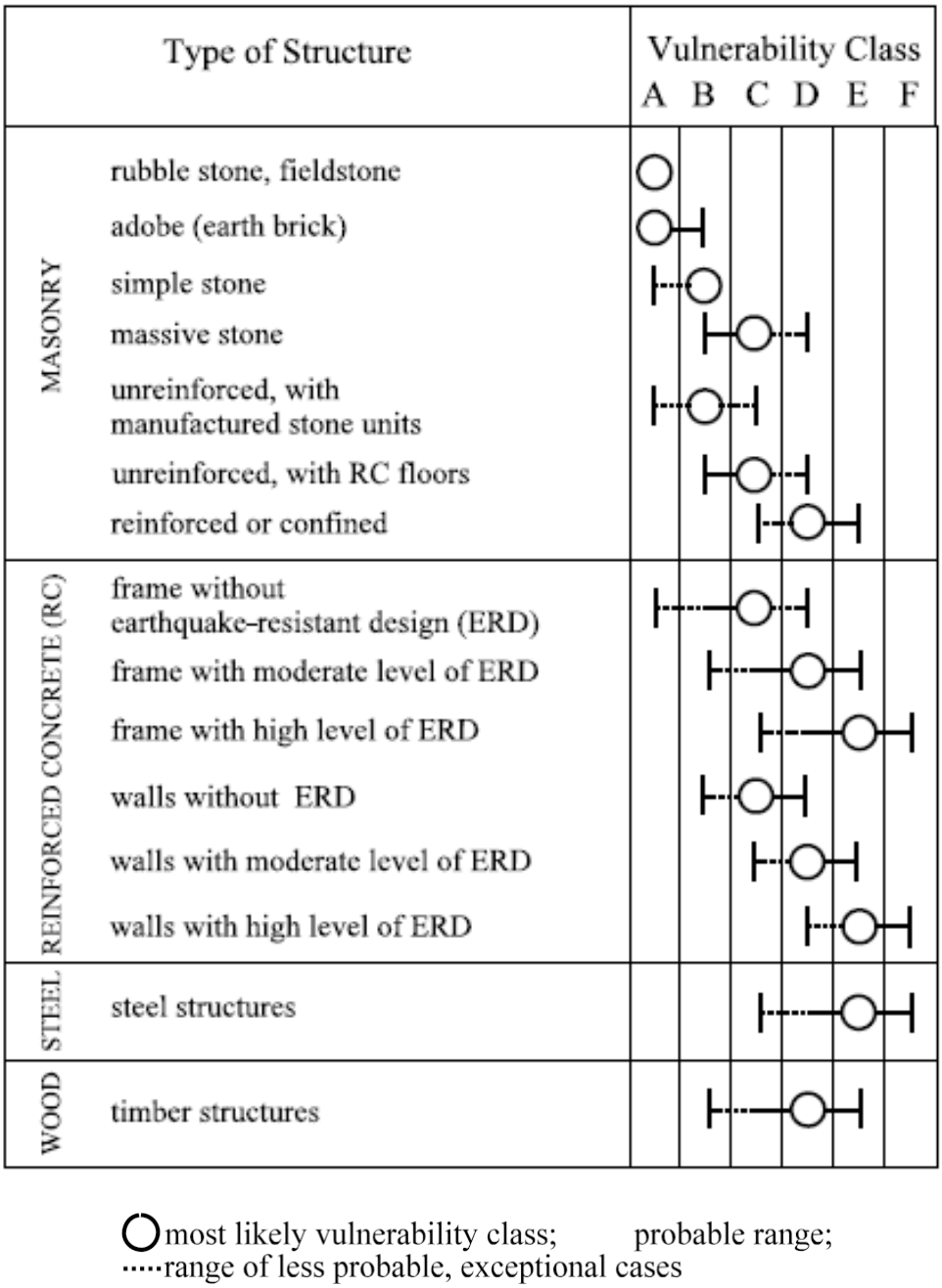
2. Classifications used in the European Macroseismic Scale (EMS)

Differentiation of structures (working group macroseismic scales 1998)
(buildings) into vulnerability classes (Vulnerability Table)

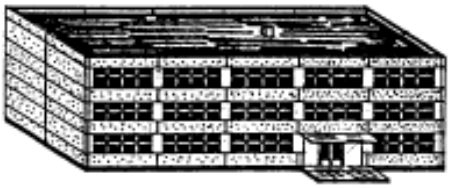
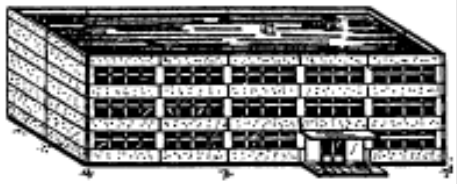
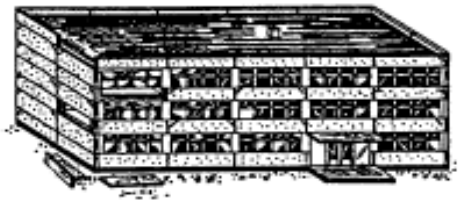
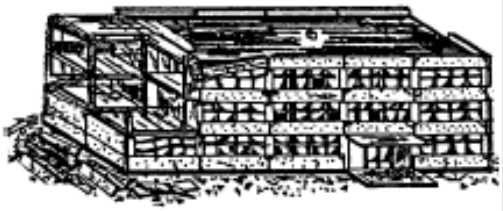
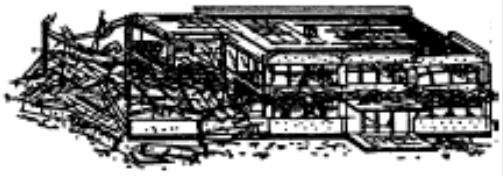


The masonry types of structures are to be read as, e.g., simple stone masonry, whereas the reinforced concrete (RC) structure types are to be read as, e.g., RC frame or RC wall.

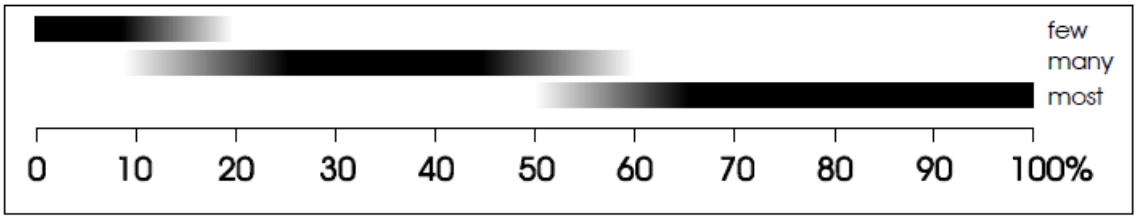
Classification of damage

Note: the way in which a building deforms under earthquake loading depends on the building type. As a broad categorisation one can group together types of masonry buildings as well asbuildings of reinforced concrete.

Classification of damage to masonry buildings	
	**Grade 1: Negligible to slight damage** **(no structural damage,** **slight non-structural damage)** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
	**Grade 2: Moderate damage** **(slight structural damage, moderate non-structural damage)** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage,** **heavy non-structural damage)** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
	**Grade 4: Very heavy damage** **(heavy structural damage,** **very heavy non-structural damage)** Serious failure of walls; partial structural failure of roofs and floors.
	**Grade 5: Destruction** **(very heavy structural damage)** Total or near total collapse.

Classification of damage to buildings of reinforced concrete	
	**Grade 1: Negligible to slight damage** **(no structural damage,** **slight non-structural damage)** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
	**Grade 2: Moderate damage** **(slight structural damage,** **moderate non-structural damage)** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage,** **heavy non-structural damage)** Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels.
	**Grade 4: Very heavy damage** **(heavy structural damage,** **very heavy non-structural damage)** Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
	**Grade 5: Destruction** **(very heavy structural damage)** Collapse of ground floor or parts (e. g. wings) of buildings.

Definitions of quantity



Definitions of intensity degrees

Arrangement of the scale:

a) Effects on humans

b) Effects on objects and on nature

c) Damage to buildings

Introductory remark:

The single intensity degrees can include the effects of shaking of the respective lower intensity degree(s) also, when these effects are not mentioned explicitly.

I. Not felt

a) Not felt, even under the most favourable circumstances.

b) No effect.

c) No damage.

II. Scarcely felt

a) The tremor is felt only at isolated instances (<1%) of individuals at rest and in a specially receptive position indoors.

b) No effect.

c) No damage.

III. Weak

a) The earthquake is felt indoors by a few. People at rest feel a swaying or light trembling.

b) Hanging objects swing slightly.

c) No damage.

IV. Largely observed

a) The earthquake is felt indoors by many and felt outdoors only by very few. A few

people are awakened. The level of vibration is not frightening. The vibration is moderate. Observers feel a slight trembling or swaying of the building, room or bed, chair etc.
b) China, glasses, windows and doors rattle. Hanging objects swing. Light furniture shakes visibly in a few cases. Woodwork creaks in a few cases.
c) No damage.

V. Strong

a) The earthquake is felt indoors by most, outdoors by few. A few people are frightened and run outdoors. Many sleeping people awake. Observers feel a strong shaking or rocking of the whole building, room or furniture.
b) Hanging objects swing considerably. China and glasses clatter together. Small, top-heavy and/or precariously supported objects may be shifted or fall down. Doors and windows swing open or shut. In a few cases window panes break. Liquids oscillate and may spill from well-filled containers. Animals indoors may become uneasy.
c) Damage of grade 1 to a few buildings of vulnerability class A and B.

VI. Slightly damaging

a) Felt by most indoors and by many outdoors. A few persons lose their balance. Many people are frightened and run outdoors.
b) Small objects of ordinary stability may fall and furniture may be shifted. In few instances dishes and glassware may break. Farm animals (even outdoors) may be frightened.
c) Damage of grade 1 is sustained by many buildings of vulnerability class A and B; a few of class A and B suffer damage of grade 2; a few of class C suffer damage of grade 1.

VII. Damaging

a) Most people are frightened and try to run outdoors. Many find it difficult to stand, especially on upper floors.
b) Furniture is shifted and top-heavy furniture may be overturned. Objects fall from shelves in large numbers. Water splashes from containers, tanks and pools.
c) Many buildings of vulnerability class A suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class B suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class C sustain damage of grade 2.
A few buildings of vulnerability class D sustain damage of grade 1.

VIII. Heavily damaging

a) Many people find it difficult to stand, even outdoors.
b) Furniture may be overturned. Objects like TV sets, typewriters etc. fall to the ground. Tombstones may occasionally be displaced, twisted or overturned. Waves may be seen on very soft ground.
c) Many buildings of vulnerability class A suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class B suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class C suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class D sustain damage of grade 2.

IX. Destructive

a) General panic. People may be forcibly thrown to the ground.
b) Many monuments and columns fall or are twisted. Waves are seen on soft ground.
c) Many buildings of vulnerability class A sustain damage of grade 5.
Many buildings of vulnerability class B suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class C suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class D suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class E sustain damage of grade 2.

X. Very destructive

c) Most buildings of vulnerability class A sustain damage of grade 5.
Many buildings of vulnerability class B sustain damage of grade 5.
Many buildings of vulnerability class C suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class D suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class E suffer damage of grade 2; a few of grade 3.
A few buildings of vulnerability class F sustain damage of grade 2.

XI. Devastating

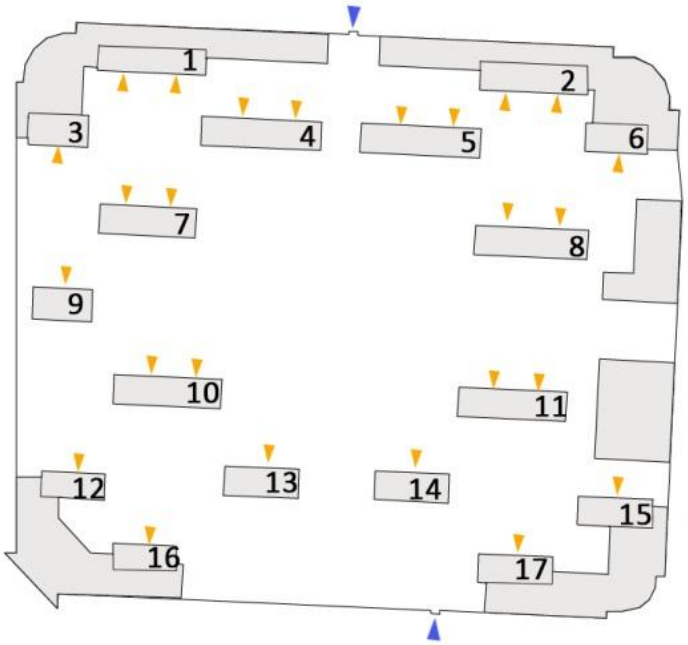
c) Most buildings of vulnerability class B sustain damage of grade 5.
Most buildings of vulnerability class C suffer damage of grade 4; many of grade 5.
Many buildings of vulnerability class D suffer damage of grade 4; a few of grade 5.
Many buildings of vulnerability class E suffer damage of grade 3; a few of grade 4.
Many buildings of vulnerability class F suffer damage of grade 2; a few of grade 3.

XII. Completely devastating

c) All buildings of vulnerability class A, B and practically all of vulnerability class C aredestroyed. Most buildings of vulnerability class D, E and F are destroyed. The earthquake
effects have reached the maximum conceivable effects

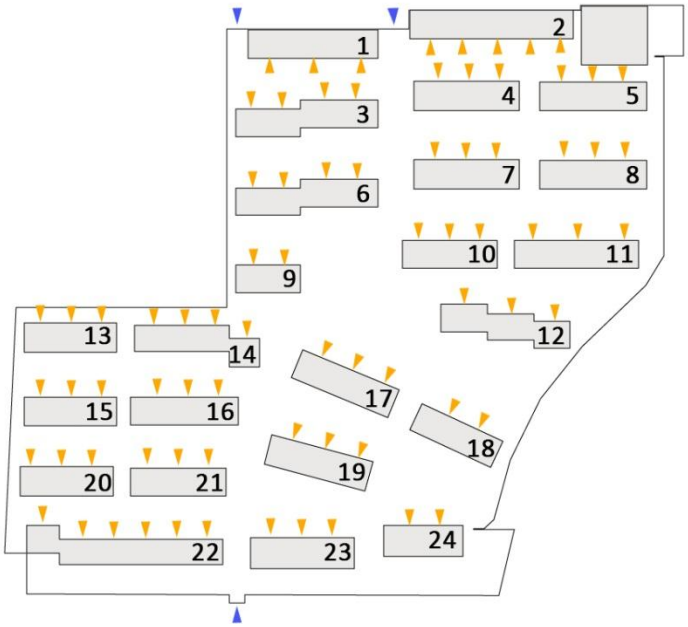
3. List of number of residents in each building

High-rise building area



Building Number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
1	614	24	2	307
2	614	24	2	307
3	307	24	1	307
4	614	24	2	307
5	614	24	2	307
6	307	24	1	307
7	614	24	2	307
8	614	24	2	307
9	307	24	1	307
10	614	24	2	307
11	614	24	2	307
12	307	24	1	307
13	307	24	1	307
14	307	24	1	307
15	307	24	1	307
16	307	24	1	307
17	307	24	1	307
Total	7675			

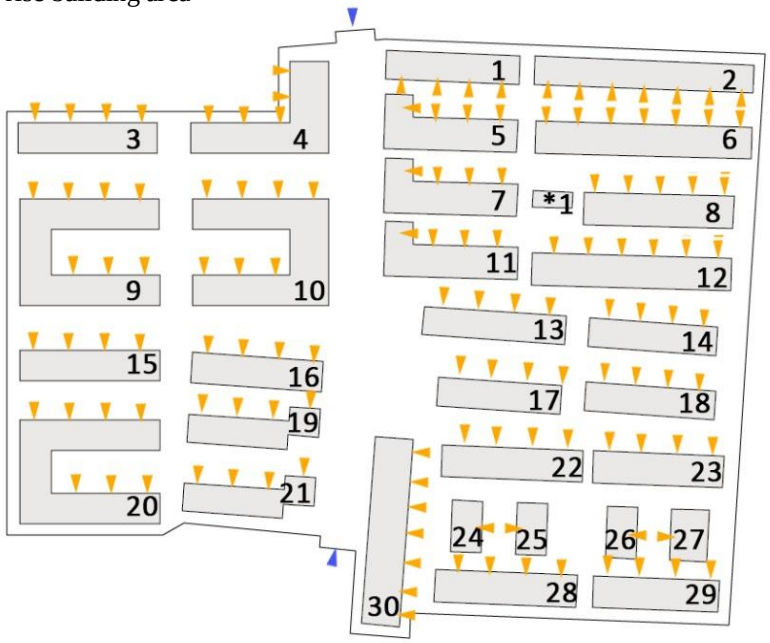
New Middle-rise building area



Building number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
1	110	6	3	36.6
2	183	6	5	36.6
3	146	6	4	36.6
4	110	6	3	36.6
5	110	6	3	36.6
6	146	6	4	36.6
7	110	6	3	36.6
8	110	6	3	36.6
9	73	6	2	36.6
10	110	6	3	36.6
11	110	6	3	36.6
12	110	6	3	36.6
13	110	6	3	36.6
14	146	6	4	36.6
15	110	6	3	36.6
16	110	6	3	36.6
17	110	6	3	36.6
18	73	6	2	36.6
19	110	6	3	36.6
20	110	6	3	36.6

Building number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
21	110	6	3	36.6
22	220	6	6	36.6
23	110	6	3	36.6
24	73	6	2	36.6
Total	2818			

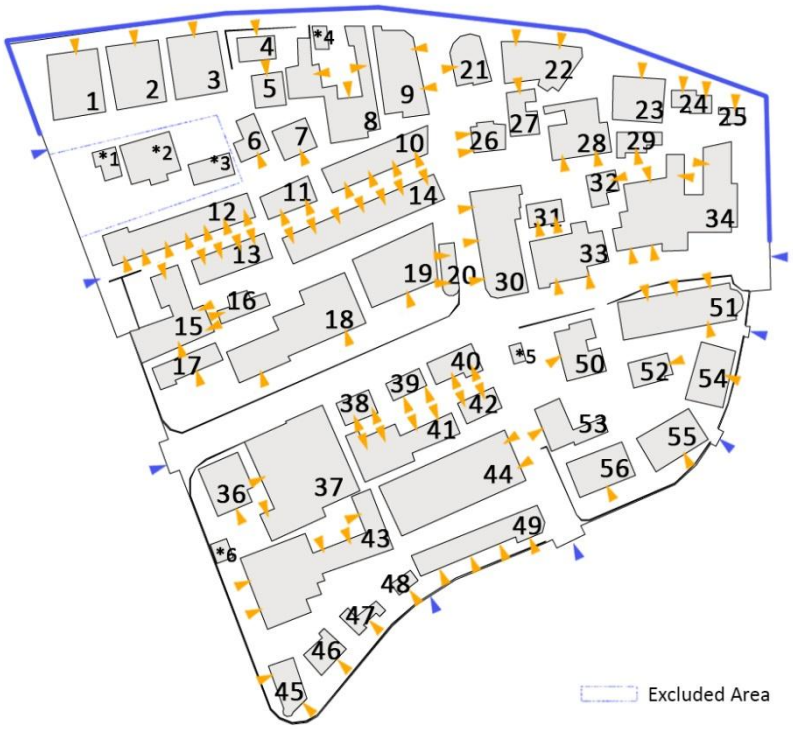
Old Middle-rise building area



Building number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
1	128	5	4	32
2	224	5	7	32
3	128	5	4	32
4	160	5	5	32
5	128	5	4	32
6	224	5	7	32
7	128	5	4	32
8	160	5	5	32
9	224	5	7	32
10	224	5	7	32
11	128	5	4	32
12	192	5	6	32
13	128	5	4	32
14	128	5	4	32
15	128	5	4	32
16	128	5	4	32
17	128	5	4	32
18	128	5	4	32
19	128	5	4	32
20	224	5	7	32

Building number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
21	128	5	4	32
22	128	5	4	32
23	128	5	4	32
24	32	5	1	32
25	32	5	1	32
26	32	5	1	32
27	32	5	1	32
28	128	5	4	32
29	128	5	4	32
30	224	5	7	32
Total	4160		4	

Traditional concession area

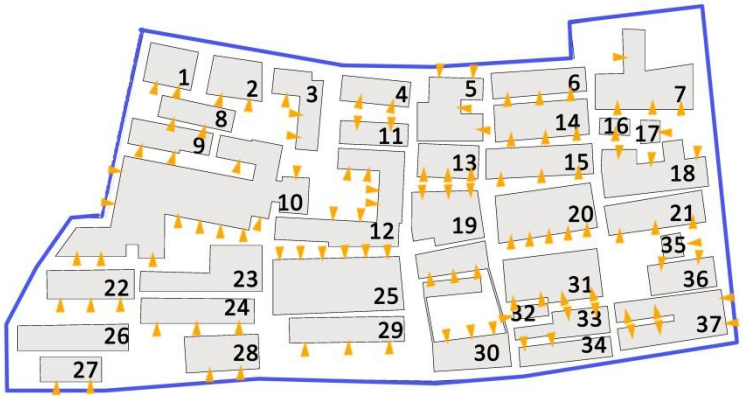


Building number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
1	64	3	1	21
2	64	3	1	21
3	64	3	1	21
4	16	3	1	5
5	19	3	1	6
6	19	3	1	6
7	22	3	1	7
8	93	3	3	31
9	67	3	2	22
10	54	3	4	18
11	38	3	2	13
12	80	3	7	27
13	38	3	4	13
14	90	3	7	30
15	96	3	3	32

Building number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
16	51	3	1	17
17	26	3	1	9
18	115	3	2	38
19	83	3	1	28
20	16	3	2	5
21	32	3	1	11
22	58	3	2	19
23	45	3	1	15
24	16	3	2	5
25	6	3	2	2
26	19	3	2	6
27	22	3	1	7
28	54	3	2	18
29	16	3	1	5
30	93	3	3	31
31	16	3	2	5
32	16	3	2	5
33	64	3	2	21
34	160	3	5	53
35	0	1	0	0
36	42	3	1	14
37	173	3	2	58
38	19	3	2	6
39	13	3	2	4
40	26	3	2	9
41	67	3	4	22
42	19	3	2	6
43	51	3	5	17
44	147	3	2	49
45	26	3	2	9
46	19	3	1	6
47	13	3	1	4
48	6	3	1	2
49	61	3	4	20
50	38	3	1	13

Building number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
51	90	3	4	30
52	19	3	1	6
53	35	3	1	12
54	45	3	1	15
55	45	3	1	15
56	45	3	1	15
Total	2733			

Traditional Neighborhood area

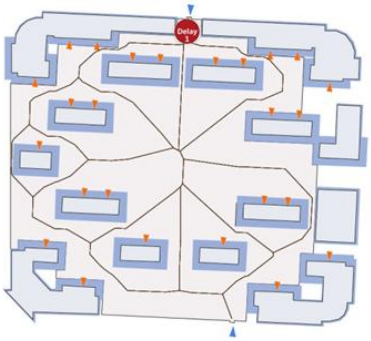


Building Number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
1	6	1	2	3.0
2	6	1	2	3.0
3	7	1	3	2.4
4	5	1	2	2.5
5	11	1	4	2.7
6	7	1	3	2.4
7	15	1	4	3.8
8	5	1	2	2.5
9	6	1	2	3.0
10	48	1	12	4.0
11	5	1	2	2.5
12	18	1	6	3.0
13	9	1	3	3.0
14	11	1	3	3.5
15	11	1	3	3.5
16	2	1	1	2.0
17	1.5	1	1	1.5
18	10	1	3	3.2
19	11	1	3	3.5
20	14	1	5	2.8

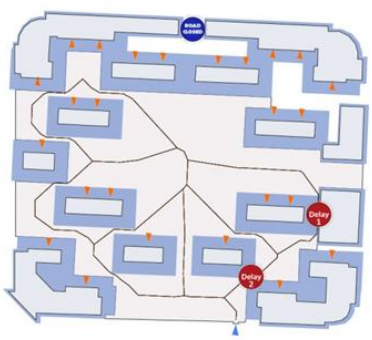
Building Number	Number of residents	Floors	Number of building entrance	Number of evacuees of each exit
22	8	1	3	2.8
23	7	1	5	1.4
24	9	1	3	3.0
25	21	1	6	3.5
26	6	1	2	3.0
27	5	1	2	2.5
28	12	1	3	4.0
29	18	1	6	3.0
30	12	1	4	3.0
31	4	1	1	3.5
32	1	1	1	1.0
33	6	1	2	3.0
34	6	1	2	3.0
35	1	1	1	1.0
36	6	1	2	3.0
37	15	1	6	2.5
Total	351			

4. Details of evacuees' delay

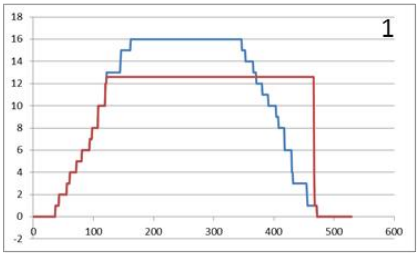
High rise building area

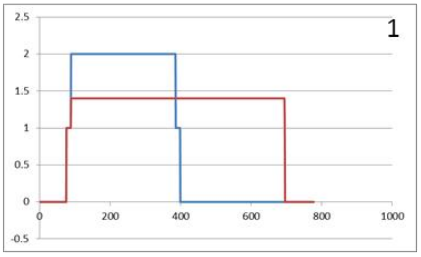


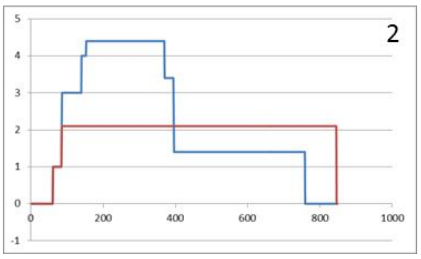
HB Damage level 1



HB Damage level 2



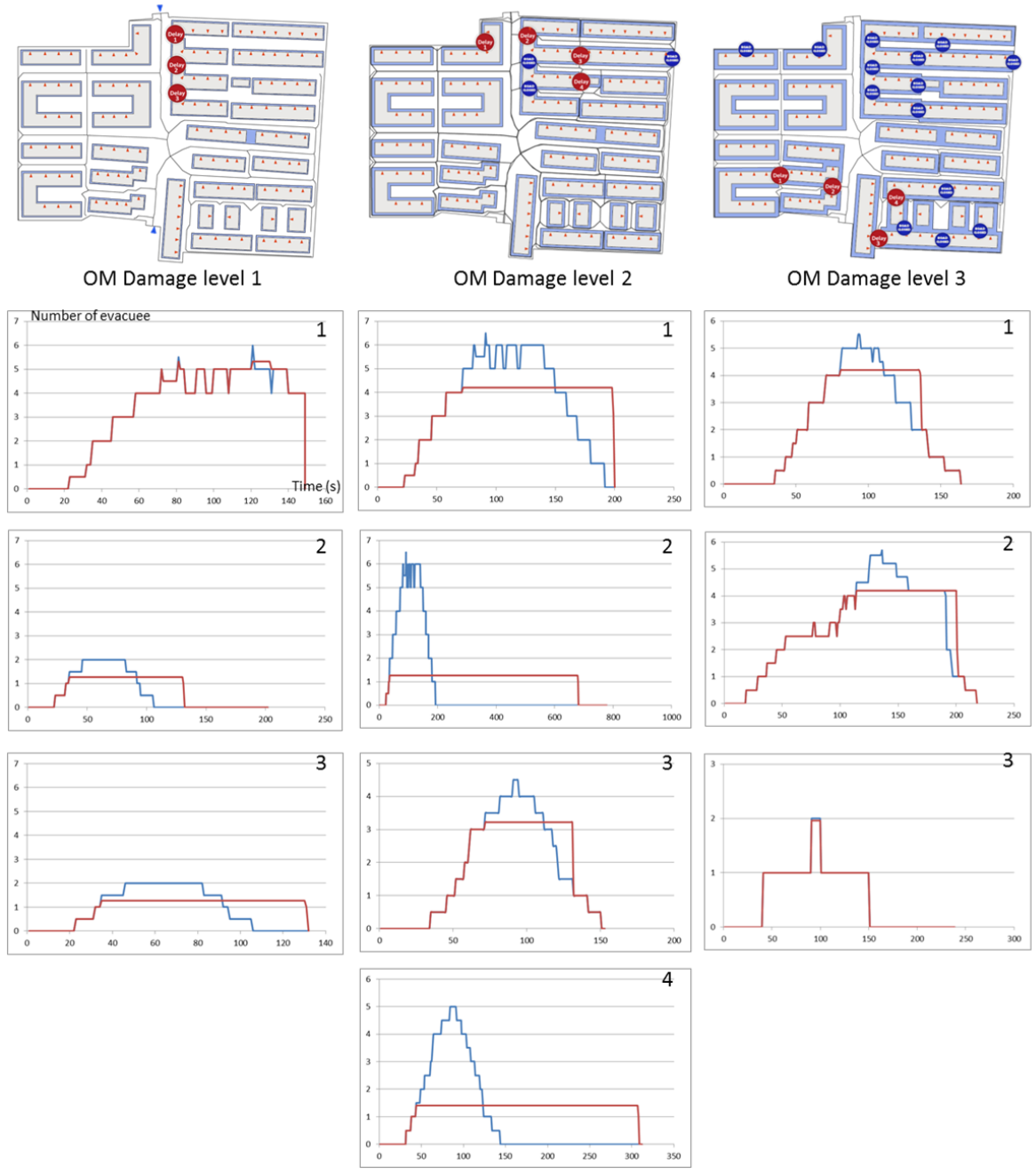




Delay Delay point ROAD CLOSED Shut down point

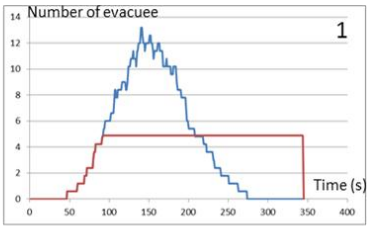
Original Flow of evacuees Flow of evacuees under damage situation

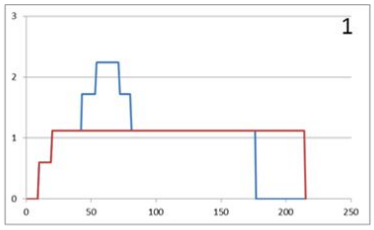
Old-middle rise building area

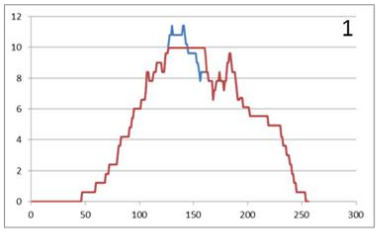


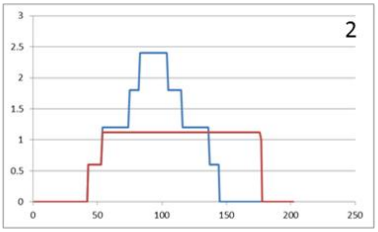
New-middle rise building area

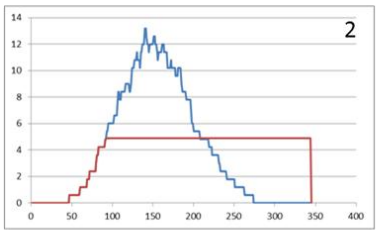
NM Damage level 1 NM Damage level 2 NM Damage level 3

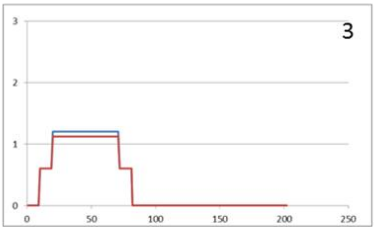


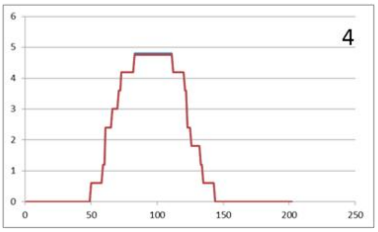










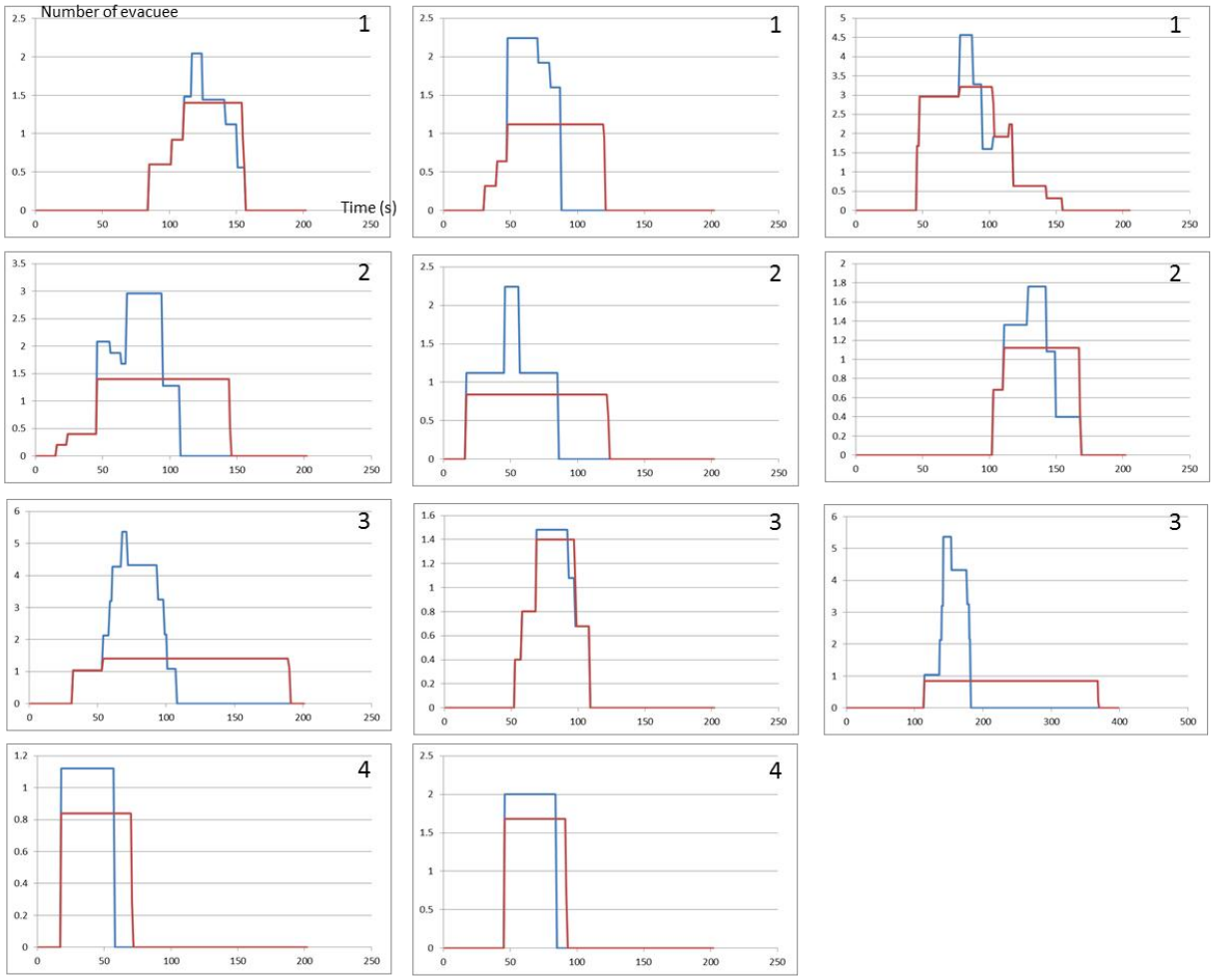


Delay point Shut down point

Original Flow of evacuees Flow of evacuees under damage situation

Traditional Condession Area

TC Damage level 1 TC Damage level 2 TC Damage level 3



Delay point Shut down point

Original Flow of evacuees Flow of evacuees under damage situation

5. Auto CAD programming 1 – Draw circles

```
(Defun C:drawcircle()
(setq dire (getstring "Please input the directory
you want to save at") )
(setq f (open (strcat dire "circle.txt") "w"))
(close f)
(setq f (open (strcat dire "circle1.txt") "w"))
(close f)
(setq f (open (strcat dire "circle2.txt") "w"))
(close f)
(setq f (open (strcat dire "circle3.txt") "w"))
(close f)
(setq f (open (strcat dire "circle6.txt") "w"))
(close f)
  (setq f (open (strcat dire "circle.txt") "a"))
  (setq f1 (open (strcat dire "circle1.txt") "a"))
  (setq f2 (open (strcat dire "circle2.txt") "a"))
  (setq f3 (open (strcat dire "circle3.txt") "a"))
(setq f4 (open (strcat dire "circle5.txt") "a"))
(setq f5 (open (strcat dire "circle6.txt") "a"))
(setq entall (ssget "X"))
(setq entlen (sslength entall))
(setq i 0)
(repeat entlen
(setq ent2 (ssname entall i))
(setq ent3 (entget ent2))
(setq ent4 (cdr(assoc 0 ent3)))
(if(= ent4 "LWPOLYLINE")
  (command "explode" ent2 "" ))
(setq i (1+ i)))
(setq k 0)
(setq line-number 0)
(while (< k entlen)
(setq ent2 (ssname entall k))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
(setq line-number (1+ line-number))))
(setq k (1+ k)))
(setq asd nil)
(setq asd-0 nil)
(setq asd-test nil)
(setq asd-test1 nil)
(setq num-cir 0)
(setq yizu nil)
(setq quanbuzu nil)
(setq yiyizugjk nil)
(setq wh-to-be 0)
(setq cao5 12342)
(setq cao6 78712)
(setq err 0.003)
(setq err1 0.0015)
(setq indica 0)
(setq min-dis 1)
(setq asd-cir nil)
(setq entall (ssget "X"))
(setq entlen (sslength entall))。。
(setq p0 (getpoint))
(setq i 0)
(setq dis 10000000)
(repeat entlen
  (setq ent2 (ssname entall i))
  (setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
  (if (< (distance p0 px) dis)
  (progn
(setq dis (distance p0 px))
(setq p1 px)))
  (if (< (distance p0 py) dis)
  (progn
(setq dis (distance p0 py))
(setq p1 py)))
  (setq i (1+ i)))
(setq num-line 0)
(setq i 0)
(setq test1 0)
(repeat entlen
  (setq ent2 (ssname entall i))
  (setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
  (if (or (equal px p1) (equal py p1))
  (progn
(setq num-line (1+ num-line))
(if (= test1 0)
  (progn
  (setq ent3 ent2)
  (setq test1 1))
  (progn
(setq ent4 ent2) ))))
(setq i (1+ i)))
(print "adasdasd")
(setq px1 (cdr (assoc 10 (entget ent3))))
(setq py1 (cdr (assoc 11 (entget ent3))))
(if (equal px1 p1)
  (setq p2 py1)
  (setq p2 px1))
(setq px2 (cdr (assoc 10 (entget ent4))))
(setq py2 (cdr (assoc 11 (entget ent4))))
(if (equal px2 p1)
  (setq p3 py2)
  (setq p3 px2))
(setq angle-p1 (/ (+ (angle p1 p2) (angle p1
p3) ) 2))
(setq p0-one (polar p1 angle-p1 0.0001))
(setq p0-two (polar p1 (+ angle-p1 3.1415926)
0.0001))
(if(and (= (inters p0-one p0 px1 py1) nil)(=
(inters p0-one p0 px2 py2) nil))
  (setq p0 p0-one)
  (setq p0 p0-two))
```

```
  (setq indi 0)
(setq test3 1)
  (while (= test3 1)
(setq test2 0)
(setq test3 0)
(setq yizu (cons p1 yizu))
(setq asd (cons p1 asd))
(setq asd-0 (cons p0 asd-0))
(setq asd-test (cons p2 (cons p3 (cons num-asd
asd-test))))
(setq asd-test1 (cons p2 (cons p3 asd-test1)))
(setq num-asd(length asd))
(setq tem-asd asd)
(repeat num-asd
  (setq tem-po (car tem-asd))
  (setq tem-asd (cdr tem-asd))
  (if (equal tem-po p2)
  (setq test2 1)))
(if (= test2 0)
(progn
  (setq test3 1)
  (setq p1-past p1)
  (setq p1 p2)
  (setq asd-test (cons "p2" asd-test)))
(progn
(setq test2 0)
(setq tem-asd asd)
(repeat num-asd
  (setq tem-po (car tem-asd))
  (setq tem-asd (cdr tem-asd))
  (if (equal tem-po p3)
(setq test2 1)))
(if (= test2 0)
(progn
  (setq test3 1)
  (setq p1-past p1)
  (setq p1 p3)
  (setq asd-test (cons "p3" asd-test))))))
  (if (= test3 1)
  (progn
(setq i 0)
(setq test1 0)
(repeat entlen
  (setq ent2 (ssname entall i))
  (setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
(if (or (equal px p1) (equal py p1))
(progn
  (if (= test1 0)
(progn
(setq ent3 ent2)
(setq test1 1))
(progn
(setq ent4 ent2) ))))
(setq i (1+ i)) )
(setq px (cdr (assoc 10 (entget ent3))))
(setq py (cdr (assoc 11 (entget ent3))))
(if (equal px p1)
  (setq p2 py)
  (setq p2 px))
(setq px (cdr (assoc 10 (entget ent4))))
(setq py (cdr (assoc 11 (entget ent4))))
(if (equal px p1)
(setq p3 py)
(setq p3 px))
(setq angle-p1 (/ (+ (angle p1 p2) (angle p1
p3) ) 2))
(setq p0-one (polar p1 angle-p1 0.0001))
(setq p0-two (polar p1 (+ angle-p1 3.1415926)
0.0001))
(if (/= (inters p0-one p0 p1 p1-past) nil)
  (setq p0 p0-two)
  (setq p0 p0-one)) )
  (progn
  (setq quanbuzu (cons yizu quanbuzu))
  (setq yizu nil)
  (setq k 0)
  (while (and (< k entlen) (= test3 0))
(setq ent2 (ssname entall k))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
  (setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
  (setq test2 0)
  (setq tem-asd asd)
  (while (and (= test2 0) (/= tem-asd nil))
(setq tem-po (car tem-asd))
(setq tem-asd (cdr tem-asd))
(if ( or (equal px tem-po) (equal py tem-po) )
  (setq test2 1)))
  (if (= test2 0)
(progn
(setq tem-asd asd)
(while ( and (= test3 0) (/= tem-asd nil))
  (setq tem-po (car tem-asd))
  (setq tem-asd (cdr tem-asd))
  (setq try-1 (polar px (angle px tem-po)
0.0001))
  (setq try-2 (polar tem-po (angle tem-po px)
0.0001))
  (setq j 0)
  (setq test4 0)
  (repeat entlen
(setq ent2 (ssname entall j))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
(setq px1 (cdr (assoc 10 (entget ent2))))
(setq py1 (cdr (assoc 11 (entget ent2))))
(if (/= (inters try-1 try-2 px1 py1) nil)
(setq test4 1))))

  (setq j (1+ j)) )
```

```
  (if (= test4 0)
(progn
(setq test3 1)
(setq p1 px)
(setq i 0)
(setq test1 0)
  (repeat entlen
  (setq ent2 (ssname entall i))
(setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
  (if (or (equal px p1) (equal py p1))
  (progn
  (if (= test1 0)
  (progn
  (setq ent3 ent2)
  (setq test1 1))
  (progn
  (setq ent4 ent2) ))))
  (setq i (1+ i)) )
(setq px1 (cdr (assoc 10 (entget ent3))))
(setq py1 (cdr (assoc 11 (entget ent3))))
(if (equal px1 p1)
(setq p2 py1)
(setq p2 px1))
(setq px2 (cdr (assoc 10 (entget ent4))))
(setq py2 (cdr (assoc 11 (entget ent4))))
(if (equal px2 p1)
  (setq p3 py2)
  (setq p3 px2))
  (setq angle-p1 (/ (+ (angle p1 p2) (angle p1
p3) ) 2))
  (setq p0-one (polar p1 angle-p1 0.0001))
  (setq p0-two (polar p1 (+ angle-p1 3.1415926)
0.0001))
  (if(and (= (inters p0-one try-1 px1 py1) nil)(=
(inters p0-one try-1 px2 py2) nil))
(setq p0 p0-one)
(setq p0 p0-two))
(setq asd-test (cons "px" asd-test)))))
(setq tem-asd asd)
(while ( and (= test3 0) (/= tem-asd nil))
  (setq tem-po (car tem-asd))
  (setq tem-asd (cdr tem-asd))
  (setq try-1 (polar py (angle py tem-po)
0.0001))
  (setq try-2 (polar tem-po (angle tem-po py)
0.0001))
  (setq j 0)
  (setq test4 0)
  (repeat entlen
(setq ent2 (ssname entall j))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
(setq px1 (cdr (assoc 10 (entget ent2))))
(setq py1 (cdr (assoc 11 (entget ent2))))
(if (/= (inters try-1 try-2 px1 py1) nil)
(setq test4 1))))
  (setq j (1+ j)) )
  (if (= test4 0)
(progn
(setq test3 1)
(setq p1 py)
(setq i 0)
(setq test1 0)
  (repeat entlen
  (setq ent2 (ssname entall i))
(setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
  (if (or (equal px p1) (equal py p1))
  (progn
  (if (= test1 0)
  (progn
  (setq ent3 ent2)
  (setq test1 1))
  (progn
  (setq ent4 ent2) ))))
  (setq i (1+ i)) )
(setq px1 (cdr (assoc 10 (entget ent3))))
(setq py1 (cdr (assoc 11 (entget ent3))))
(if (equal px1 p1)
(setq p2 py1)
(setq p2 px1))
(setq px2 (cdr (assoc 10 (entget ent4))))
(setq py2 (cdr (assoc 11 (entget ent4))))
(if (equal px2 p1)
  (setq p3 py2)
  (setq p3 px2))
  (setq angle-p1 (/ (+ (angle p1 p2) (angle p1
p3) ) 2))
  (setq p0-one (polar p1 angle-p1 0.0001))
  (setq p0-two (polar p1 (+ angle-p1 3.1415926)
0.0001))
  (if(and (= (inters p0-one try-1 px1 py1) nil)(=
(inters p0-one try-1 px2 py2) nil))
(setq p0 p0-one)
(setq p0 p0-two))
(setq asd-test (cons "py" asd-test)))))))))
  (setq k (1+ k))))))
  (setq min-rr(getint "Dear miss MA, it is about
to draw the circles. Please input an integer to
indicate the minimum radius you require: "))
  (setq min-r (/ min-rr 100.0))
(setq asd-tem asd)
(setq asd-0-tem asd-0)
(setq asd-test1-tem asd-test1)
(setq time 0)
(repeat num-asd
  (setq time (1+ time))
  (setq p1 (car asd-tem))
  (setq asd-tem (cdr asd-tem))
  (setq p0 (car asd-0-tem))
  (setq asd-0-tem (cdr asd-0-tem))
  (setq p2 (car asd-test1-tem))
```

```
  (setq asd-test1-tem (cdr asd-test1-tem))
  (setq p3 (car asd-test1-tem))
  (setq asd-test1-tem (cdr asd-test1-tem))

(setq quanbuzu-tem quanbuzu)
  (setq testzu 0)
  (setq yizu1-indi 0)
  (while (and (= testzu 0) (setq yizu1 (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu1-indi (1+ yizu1-indi))
  (if (/= (member p1 yizu1) nil)
  (setq testzu 1)))
#chuixian

(setq ang1 (abs (- (angle p1 p0) (angle p1 p3))))
(if (> ang1 3.1415926)
(setq ang1 (- 6.2831852 ang1 )))
(setq ang2 (abs (- (angle p1 p0) (angle p1 p2))))
(if (> ang2 3.1415926)
(setq ang2 (- 6.2831852 ang2 )))
(setq jiaodu (+ang1 ang2 ))
(if (> jiaodu 3.1415926)
(progn
(setq i 0)
(repeat entlen
  (setq ent2 (ssname entall i))
  (setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
  (if (and (and (= (equal p1 px) nil) (= (equal p1
py) nil))
(= (member px yizu1) nil) )
  (progn
  (setq ang1 (abs (- (angle px p1) (angle px
py))))
  (if (> ang1 3.1415926)
(setq ang1 (- 6.2831852 ang1 )))
  (setq ang2 (abs (- (angle py p1) (angle py
px))))
  (if (> ang2 3.1415926)
(setq ang2 (- 6.2831852 ang2 )))
  (if (> ang1 (/ 3.1415926 2))
  (progn
  (progn
  (if (> ang2 (/ 3.1415926 2))
  (progn)
  (progn
(setq distem ( / (* (cos ang2) (distance p1 py))
(distance px py)))
(setq rp4(- (/ (* (distance p1 py) (sin ang2)) 2)
err))
(setq p4 (list (/ (+ (+(* (- (car px) (car py))
distem) (car py)) (car p1)) 2) (/(+ (+ (* (- (cadr
px) (cadr py)) distem) (cadr py)) (cadr p1))
2)(caddr p1)))
(setq test1 0)
  (setq bb 0)
(while (and (< bb (/ (length asd-cir) 2)) (= test1
0))
  (setq yuan (nth (* 2 bb) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 bb)) asd-cir))
  (if (< (distance yuan p4) min-dis)
(progn
(setq test1 1)))
  (setq bb (1+ bb)))
  (if (< rp4 min-r)
  (setq test1 1))
(setq num-lin 0)
(if (= test1 0)
(progn
(setq k 0)
(while (and (< k entlen) (= test1 0) )
(setq ent2 (ssname entall k))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
  (setq num-lin (1+ num-lin))
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
(setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
(if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
(if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1)))
  (progn
(if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1)))
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1))))))))
  (setq k (1+ k)) )))
  (if (/= test1 1)
  (progn
  (command "circle" p4 rp4 "")
  (setq num-cir (1+ num-cir))
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (setq asd-cir (cons p4 (cons rp4 asd-cir)))
```

```
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member px yizu-tem) nil)
  (setq testzu 1)))
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
(setq 3-yizu nil)
(setq 3-yizu (cons yizu-tem-indi (cons yizu1-indi 3-yizu)))
(setq j 0)
(setq k 1)
  (if (< (nth j 3-yizu) (nth k 3-yizu))
(progn
  (setq tem (nth j 3-yizu))
  (setq temr (nth k 3-yizu))
  (setq 3-yizu
  (subst cao5 (nthk 3-yizu) 3-yizu))
  (setq 3-yizu
  (subst cao6 (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtemr (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtem (nthk 3-yizu) 3-yizu))))
(if (= (member 3-yizu yiyizugjk) nil)
  (setq yiyizugjk (cons 3-yizu yiyizugjk)))
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) ))))))
(setq i (1+ i)))
)
(progn))
######################


  (if (> jiaodu 3.1415926)
  (progn
  (setq p1-tan1 (polar p1 (+ (angle p1 p0) (- (/ jiaodu 2) (/ 3.1415926 2)) ) 100))
  (setq p1-tan2 (polar p1 (- (angle p1 p0) (- (/ jiaodu 2) (/ 3.1415926 2)) ) 100))
  (setq i 0)
(repeat entlen
(setq ent2 (ssname entall i))
  (setq px (cdr (assoc 10 (entget ent2))))
  (setq py (cdr (assoc 11 (entget ent2))))
  (if (or (/= (member px yizu1) nil) (/= (member py yizu1) nil) )
  (progn
  )
  (progn

  (setq test-ang (abs (- (angle p1 p1-tan1) (angle px py))))
  (if (> test-ang 3.1415926)
(setq test-ang (- 6.2831852 test-ang ))
  )
  (if (and (> (abs (- test-ang (/ 3.1415926 2))) 0.0001)
  (and (> test-ang 0.0001) (> (abs (- test-ang 3.1415926)) 0.0001) ))
(progn
  (setq p5 (polar p1 (+(angle p1 p1-tan1) (/ 3.1415926 2)) 1000))
  (setq inter1 (inters px py p1 p5 nil))
  (setq angle1 (/ (+ (angle p1 p5) (angle px py)) 2))
  (setq angle2 (+ angle1 (/ 3.1415926 2)))
  (setq p6 (polar inter1 angle1 1000))
  (setq p7 (polar inter1 angle2 1000))
  (setq inter2 (inters inter1 p6 p1 p1-tan1 nil))
  (setq inter3 (inters inter1 p7 p1 p1-tan1 nil))
  (if (> (* (- (car p1) (car p1-tan1))(- (car p1) (car inter2))) 0)
  (setq jiaodian inter2)
  (setq jiaodian inter3))
  (print "jjjj")
  (setq test-po (polar inter1 (+ (angle inter1 jiaodian) (- (angle inter1 jiaodian) (angle inter1 p1))) (distance inter1 p1)))
  (if (or (< (* (- (car test-po)(car px)) (- (car test-po) (car py)) ) 0) (< (* (- (cadr test-po)(cadr px)) (- (cadr test-po) (cadr py)) ) 0))
  (progn
  (setq rp4 (- (distance jiaodian p1) err))
  (setq p4 jiaodian)
  (print "asdfsfdf")
  (setq k 0)
  (setq test1 0)
  (setq bb 0)
(while (and (< bb (/ (length asd-cir) 2)) (= test1 0))
  (setq yuan (nth (* 2 bb) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 bb)) asd-cir))
  (if (< (distance yuan p4) min-dis)
(progn
(setq test1 1))
  (setq bb (1+ bb)))
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1 py1))))
  (if (> ang3 3.1415926)
```

```
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 ))
)
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1)))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1)) )
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1))))))))
  (setq k (1+ k)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (setq asd-cir (cons p4 (cons rp4 asd-cir)))
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member px yizu-tem) nil)
  (setq testzu 1)))
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
(setq 3-yizu nil)
(setq 3-yizu (cons yizu-tem-indi (cons
yizu1-indi 3-yizu)))
(setq j 0)
(setq k 1)
  (if (< (nth j 3-yizu) (nth k 3-yizu))
(progn
  (setq tem (nth j 3-yizu))
  (setq temr (nth k 3-yizu))
  (setq 3-yizu
  (subst cao5 (nthk 3-yizu) 3-yizu))
  (setq 3-yizu
  (subst cao6 (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtemr (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtem (nthk 3-yizu) 3-yizu)) ))
(if (= (member 3-yizu yiyizugjk) nil)
  (setq yiyizugjk (cons 3-yizu yiyizugjk))
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) ))))))
  (setq test-ang (abs (- (angle p1 p1-tan2) (angle
px py))))
  (if (> test-ang 3.1415926)
(setq test-ang (- 6.2831852 test-ang )))
  (if(and (> (abs (- test-ang (/ 3.1415926 2)))
0.0001)
(and (> test-ang 0.0001) (> (abs (- test-ang
3.1415926)) 0.0001) ))
(progn
  (setq p5 (polar p1 (+(angle p1 p1-tan2) (/
3.1415926 2)) 1000))
  (setq inter1 (inters px py p1 p5 nil))
  (setq angle1 (/ (+ (angle p1 p5) (angle px py))
2))
  (setq angle2 (+ angle1 (/ 3.1415926 2)))
  (setq p6 (polar inter1 angle1 1000))
  (setq p7 (polar inter1 angle2 1000))
  (setq inter2 (inters inter1 p6 p1 p1-tan2 nil))
  (setq inter3 (inters inter1 p7 p1 p1-tan2 nil))
  (if (> (* (- (car p1) (car p1-tan2))(- (car p1)
(car inter2))) 0)
  (setq jiaodian inter2)
  (setq jiaodian inter3))
  (print "jjjj")
  (setq test-po (polar inter1 (+ (angle inter1
jiaodian) (- (angle inter1 jiaodian) (angle inter1
p1))) (distance inter1 p1)))
  (if (or (< (* (- (car test-po)(car px)) (- (car
test-po) (car py)) ) 0) (< (* (- (cadr
test-po)(cadr px)) (- (cadr test-po) (cadr py)) )
0))
  (progn



  (setq rp4 (- (distance jiaodian p1) err))
  (setq p4 jiaodian)
  (print "asdfsfdf")
  (setq k 0)
  (setq test1 0)
  (setq bb 0)
(while (and (< bb (/ (length asd-cir) 2)) (= test1
0))
  (setq yuan (nth (* 2 bb) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 bb)) asd-cir))
  (if (< (distance yuan p4) min-dis)
(progn
(setq test1 1)))
  (setq bb (1+ bb)))
```

```
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1)))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1)) )
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1))))))))
  (setq k (1+ k)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
(setq asd-cir (cons p4 (cons rp4 asd-cir)))
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member px yizu-tem) nil)
  (setq testzu 1)))
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
(setq 3-yizu nil)
(setq 3-yizu (cons yizu-tem-indi (cons
yizu1-indi 3-yizu)))
(setq j 0)
(setq k 1)
  (if (< (nth j 3-yizu) (nth k 3-yizu))
(progn
  (setq tem (nth j 3-yizu))
  (setq temr (nth k 3-yizu))
  (setq 3-yizu
  (subst cao5 (nthk 3-yizu) 3-yizu))
  (setq 3-yizu
  (subst cao6 (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtemr (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtem (nthk 3-yizu) 3-yizu)) ))
(if (= (member 3-yizu yiyizugjk) nil)
  (setq yiyizugjk (cons 3-yizu yiyizugjk)))
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) ))))))))
  (setq i (1+ i)) )
  (setq asd-tem1 asd)
  (repeat num-asd
(setq tem-po (car asd-tem1))
(setq asd-tem1 (cdr asd-tem1))
(setq test1 0)
(if (and (= (equal tem-po p1) nil) (= (member
tem-po yizu1) nil) )
  (progn
  (setq ang3 (abs (- (angle p1 tem-po) (angle p1
p1-tan1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (if (< ang3 (/ 3.1415926 2))
  (progn
  (print "asdasfdsf")
  (setq rp4 (- (/ (/ (distance p1 tem-po) (cos
ang3)) 2) err))
  (setq p4 (polar p1 (+ (angle p1 p0) (- (/ jiaodu
2) (/ 3.1415926 2)) ) ( + rp4 err)))
  (print "asdfsfdf")
  (setq k 0)
  (setq bb 0)
(while (and (< bb (/ (length asd-cir) 2)) (= test1
0))
  (setq yuan (nth (* 2 bb) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 bb)) asd-cir))
  (if (< (distance yuan p4) min-dis)
(progn
(setq test1 1)))
  (setq bb (1+ bb)))
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
```

```
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 ))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1)))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1)) )
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1)))))) ))
  (setq k (1+ k)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
(setq asd-cir (cons p4 (cons rp4 asd-cir)))
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member tem-po yizu-tem) nil)
  (setq testzu 1)))
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
(setq 3-yizu nil)
(setq 3-yizu (cons yizu-tem-indi (cons
yizu1-indi 3-yizu)))
(setq j 0)
(setq k 1)
  (if (< (nth j 3-yizu) (nth k 3-yizu))
(progn
  (setq tem (nth j 3-yizu))
  (setq temr (nth k 3-yizu))
  (setq 3-yizu
  (subst cao5 (nthk 3-yizu) 3-yizu) )
  (setq 3-yizu
  (subst cao6 (nthj 3-yizu) 3-yizu) )
  (setq 3-yizu
  (substtemr (nthj 3-yizu) 3-yizu) )
  (setq 3-yizu
  (substtem (nthk 3-yizu) 3-yizu))) )
(if (= (member 3-yizu yiyizugjk) nil)
  (setq yiyizugjk (cons 3-yizu yiyizugjk)) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3))))))
(setq test1 0)
  (setq ang3 (abs (- (angle p1 tem-po) (angle p1
p1-tan2))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (if (< ang3 (/ 3.1415926 2))
  (progn
  (print "asdasfdsf")
  (setq rp4 (- (/ (/ (distance p1 tem-po) (cos
ang3)) 2) err))
  (setq p4 (polar p1 (- (angle p1 p0) (- (/ jiaodu
2) (/ 3.1415926 2)) ) (+ rp4 err)))
  (print "asdfsfdf")
  (setq bb 0)
(while (and (< bb (/ (length asd-cir) 2)) (= test1
0))
  (setq yuan (nth (* 2 bb) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 bb)) asd-cir))
  (if (< (distance yuan p4) min-dis)
(progn
(setq test1 1) ))
  (setq bb (1+ bb)))
  (if (< rp4 min-r)
  (setq test1 1) )

  (setq k 0)
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 ))
)
  (if (> ang3 (/ 3.1415926 2))
```

```
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1) ) )
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1)))
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1)) )) ))))
  (setq k (1+ k)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (setq asd-cir (cons p4 (cons rp4 asd-cir)))
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member tem-po yizu-tem) nil)
  (setq testzu 1)))
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
(setq 3-yizu nil)
(setq 3-yizu (cons yizu-tem-indi (cons
yizu1-indi 3-yizu)))
(setq j 0)
(setq k 1)
  (if (< (nth j 3-yizu) (nth k 3-yizu))
(progn
  (setq tem (nth j 3-yizu))
  (setq temr (nth k 3-yizu))
  (setq 3-yizu
  (subst cao5 (nthk 3-yizu) 3-yizu))
  (setq 3-yizu
  (subst cao6 (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtemr (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtem (nthk 3-yizu) 3-yizu) ))
(if (= (member 3-yizu yiyizugjk) nil)
  (setq yiyizugjk (cons 3-yizu yiyizugjk)) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )))))))))

######################

)

(setq indica 1)
########################################
##
(setq yiyizugjk1 nil)
(setq i 0)
(setq yiyizugjk-tem yiyizugjk)
(repeat (length yiyizugjk-tem)
(setq woqu (nth i yiyizugjk-tem))
(setq j (+ 1 i))
(repeat (- (length yiyizugjk-tem) (+ 1 i))
  (setq niqu (nth j yiyizugjk-tem))
  (if (= (nth 0 woqu) (nth 1 niqu))
  (progn
  (setq 3-yizu nil)
  (setq 3-yizu (cons (nth 0 niqu) (cons (nth 1
niqu) (cons (nth 1 woqu) 3-yizu))))

  (if (= (member 3-yizu yiyizugjk1) nil)
  (setq yiyizugjk1 (cons 3-yizu yiyizugjk1))) ) )
  (if (= (nth 1 woqu) (nth 0 niqu))
  (progn
  (setq 3-yizu nil)
  (setq 3-yizu (cons (nth 0 woqu) (cons (nth 1
woqu) (cons (nth 1 niqu) 3-yizu))))
  (if (= (member 3-yizu yiyizugjk1) nil)
  (setq yiyizugjk (cons 3-yizu yiyizugjk)) ) )
  (setq j (1+ j)) )
(setq i (1+ i)))

########################################
#########################

(setq ii 0)
(repeat 1
(setq all-line nil)

(setq 3-yizu (nth ii yiyizugjk))
  (setq jj 0)
(repeat (length 3-yizu)
  (setq kk 0)
  (repeat (length (nth (nth jj 3-yizu) quanbuzu))
  (setq asdasd (cons (nth kk (nth (nth jj 3-yizu)
quanbuzu)) asd))
(setq kk (1+ kk)))
  (setq jj (1+ jj)))
(setq asd-tem asd)
(setq asd-0-tem asd-0)
(setq asd-test1-tem asd-test1)
(setq time 0)
(repeat num-asd
```

```
  (setq time (1+ time))
  (setq p1 (car asd-tem))
  (setq asd-tem (cdr asd-tem))
  (setq p0 (car asd-0-tem))
  (setq asd-0-tem (cdr asd-0-tem))
  (setq p2 (car asd-test1-tem))
  (setq asd-test1-tem (cdr asd-test1-tem))
  (setq p3 (car asd-test1-tem))
  (setq asd-test1-tem (cdr asd-test1-tem))

(setq quanbuzu-tem quanbuzu)
  (setq testzu 0)
  (setq yizu1-indi 0)
  (while (and (= testzu 0) (setq yizu1 (car
quanbuzu-tem)))
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu1-indi (1+ yizu1-indi))
  (if (/= (member p1 yizu1) nil)
  (setq testzu 1)))
#chuixian

#chuixian

  (setq ang1 (abs (- (angle p1 p0) (angle p1
p3))))
  (if (> ang1 3.1415926)
  (setq ang1 (- 6.2831852 ang1 )))
  (setq ang2 (abs (- (angle p1 p0) (angle p1
p2))))
  (if (> ang2 3.1415926)
  (setq ang2 (- 6.2831852 ang2 )) )
  (setq jiaodu (+ang1 ang2 ))
  (if (> jiaodu 3.1415926)
(progn
(setq asd-tem1 asd-tem)
(setq asd-0-tem1 asd-0-tem)
(setq asd-test1-tem1 asd-test1-tem)
(setq num-asd1 (length asd-tem1))
(repeat num-asd1
  (setq p11 (car asd-tem1))
  (setq asd-tem1 (cdr asd-tem1))
  (setq p00 (car asd-0-tem1))
  (setq asd-0-tem1 (cdr asd-0-tem1))
  (setq p22 (car asd-test1-tem1))
  (setq asd-test1-tem1 (cdr asd-test1-tem1))
  (setq p33 (car asd-test1-tem1))
  (setq asd-test1-tem1 (cdr asd-test1-tem1))
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu2-indi 0)
(while (and (= testzu 0) (setq yizu2 (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu2-indi (1+ yizu2-indi))
  (if (/= (member p11 yizu2) nil)
  (setq testzu 1) ) )

  (setq ang11 (abs (- (angle p11 p00) (angle p11
p33))))
  (if (> ang11 3.1415926)
  (setq ang11 (- 6.2831852 ang11 )) )
(setq ang22 (abs (- (angle p11 p00) (angle p11
p22))))
(if (> ang22 3.1415926)
  (setq ang22 (- 6.2831852 ang22 )) )

(setq jiaodu1 (+ang11 ang22 ))
(if (> jiaodu1 (/ 3.1415926 2))
(progn

  (setq k 0)
  (setq test1 0)
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))

  (if (and (/= (inters p1 p11 px1 py1) nil)(and
(and (and (= (equal p11 px1) nil) (= (equal p11
py1) nil)) (= (equal p1 px1) nil)) (= (equal p1
py1) nil ) ))
  (setq test1 1) )))
(setq k (1+ k)) )
  (if (= test1 0)
(progn
# 2p1l
(setq j 0)
(repeat entlen
(setq ent2 (ssname entall j))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
  (setq px (cdr (assoc 10 (entget ent2 ))))
  (setq py (cdr (assoc 11 (entget ent2 ))))

  (print "2p1l lea")
  (write-line "" f4)
  (write-line (strcat "(" (rtos (car p1)) " " (rtos
(cadr p1)) " " (rtos (caddr p1)) ")") f4)
  (write-line (strcat "(" (rtos (car p11)) " " (rtos
(cadr p11)) " " (rtos (caddr p11)) ")") f4)
(write-line (strcat "(" (rtos (car px)) " " (rtos
(cadr px)) " " (rtos (caddr px)) ")") f4)
(write-line (strcat "(" (rtos (car py)) " " (rtos
(cadr py)) " " (rtos (caddr py)) ")") f4)
(setq test-ang (abs (- (angle py px) (angle p1
p11))))
  (if (> test-ang 3.1415926)
  (setq test-ang (- 6.2831852 test-ang))
  )
(if (and (> test-ang 0.0001) (> (abs (- test-ang
```

```
3.1415926)) 0.0001) )
  (progn
(setq test-jiao (inters px py p1 p11 nil))
(setq posi (- (length quanbuzu) 1))
(if (and ( and (and (and (and (= (equal p11 px)
nil) (= (equal p11 py) nil)) (= (equal p1 px)
nil)) (= (equal p1 py) nil ) )
(or (> (* (- (car test-jiao) (car p1)) (- (car
test-jiao) (car p11))) 0) (> (* (- (cadr test-jiao)
(cadr p1)) (- (cadr test-jiao) (cadr p11))) 0))
  ) (or (= (member px yizu1) nil)(and
(and(member p1 (nth posi quanbuzu)) (member
px (nth posi quanbuzu)) ) (member p11 (nth
posi quanbuzu)) )))
(progn

(setq p5 (list (/ (+ (car p1) (car p11)) 2) (/ (+
(cadr p1) (cadr p11)) 2) (caddr p1) ))
(setq p6 (polar p5 (+(angle p1 p11) (/
3.1415926 2)) 1000))
(setq inter1 (inters px py p1 p11 nil))
(setq angle1 (/ (+ (angle p1 p11) (angle px py))
2))
(setq angle2 (+ angle1 (/ 3.1415926 2)))
(setq p7 (polar inter1 angle1 1000))
(setq p8 (polar inter1 angle2 1000))
(setq inter2 (inters inter1 p7 p5 p6 nil))
(setq inter3 (inters inter1 p8 p5 p6 nil))
(if (> (distance inter3 p1) (distance inter2 p1))
(setq jiaodian inter2)
(setq jiaodian inter3) )
(setq p9 (inters p5 p6 px py nil))

(write-line "bupingxing" f4)
  (write-line (strcat "(" (rtos (car jiaodian)) " "
(rtos (cadr jiaodian)) " " (rtos (caddr jiaodian))
")") f4)
  (write-line (strcat "(" (rtos (car inter1)) " "
(rtos (cadr inter1)) " " (rtos (caddr inter1)) ")")
f4)

#tiaozhengjingdu

  (setq ang3 (abs (- (angle px p1) (angle px
py))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )

  (setq ang4 (abs (- (angle px p11) (angle px
py))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
  (if (< (* (sin ang3) (distance p1 px)) (* (sin
ang4) (distance p11 px)))
(setq p10 p1)
(setq p10 p11) )
  (setq p13 (polar p10 (+ (angle px py) (/
3.1415926 2)) 100))

  (setq p12 (inters p13 p10 p5 p6 nil))

  (setq ang3 (abs (- (angle px p12) (angle px
py))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (write-line (strcat "(" (rtos (car p12)) " " (rtos
(cadr p12)) " " (rtos (caddr p12)) ")") f4)

####newone
  (if (< (distance p1 p12) (* (sin ang3) (distance
p12 px)))
  (progn
  (setq diana jiaodian)
  (setq dianb p12)
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))

  (setq ang3 (abs (- (angle px dianc) (angle px
py))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 ))
  )
  (setq juli2 (* (distance dianc px) (sin ang3)))
  (setq jindu (abs (- juli1 juli2)))
  (setq repe-num 0)
  (while (and (> jindu err1) (< repe-num 200))
  (setq repe-num (1+ repe-num))
  (if (> juli1 juli2)
(progn
(setq diana dianc) )
(progn
(setq dianb dianc)) )
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))
  (setq ang3 (abs (- (angle px dianc) (angle px
py))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (setq juli2 (* (distance dianc px) (sin ang3)))
  (setq jindu (abs (- juli1 juli2))) )
(setq jiaodian dianc)

####newone

#tiaozhengjingdu
(setq test-po (polar inter1 (angle inter1 p9) (sqrt
(abs (- (* (distance inter1 jiaodian) (distance
inter1 jiaodian)) (* (distance jiaodian p1)
(distance jiaodian p1)))))))
```

```
(if (or (< (* (- (car test-po)(car px)) (- (car test-po) (car py)) ) 0) (< (* (- (cadr test-po)(cadr px)) (- (cadr test-po) (cadr py)) ) 0))
 (progn
 (setq rp4 (- (distance jiaodian p1) err))
 (setq p4 jiaodian)
 (print "asdfsfdf")
 (setq k 0)
 (setq test1 0)
 (if (< rp4 min-r)
 (setq test1 1) )
 (while (and (< k entlen) (= test1 0) )
 (setq ent2 (ssname entall k))
 (setq ent3 (cdr (assoc 0 (entget ent2))))
 (if(= ent3 "LINE")
 (progn
 (setq px1 (cdr (assoc 10 (entget ent2 ))))
 (setq py1 (cdr (assoc 11 (entget ent2 ))))
 (setq ang3 (abs (- (angle px1 p4) (angle px1 py1))))
 (if (> ang3 3.1415926)
 (setq ang3 (- 6.2831852 ang3 )) )
 (setq ang4 (abs (- (angle py1 p4) (angle py1 px1))))
 (if (> ang4 3.1415926)
 (setq ang4 (- 6.2831852 ang4 )) )
 (if (> ang3 (/ 3.1415926 2))
 (progn
(if (< (distance px1 p4) rp4)
(setq test1 1) ) )
 (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1) ))
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1) ))))) ))
 (setq k(1+ k))
)
 (if (/= test1 1)
 (progn
 (setq num-cir (1+ num-cir))
 (command "circle" p4 rp4 "")

 (setq en (entlast))
 (setq ed (entget en))
 (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr p4))) (assoc 10 ed) ed) )
 (entmod ed)
 (write-line (strcat "(" (rtos (car p4)) " " (rtos (cadr p4)) " " (rtos (caddr p4)) ")") f)
 (write-line (rtos rp4)f)
 (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car quanbuzu-tem)) )
 (setq quanbuzu-tem (cdr quanbuzu-tem))
 (setq yizu-tem-indi (1+ yizu-tem-indi))
 (if (/= (member px yizu-tem) nil)
 (setq testzu 1) ) )
(if (and (/= yizu2-indi yizu-tem-indi) (/= yizu1-indi yizu2-indi) )

(progn
 (write-line (rtos 3) f1)
 (write-line (rtos yizu1-indi)f1)
 (write-line (rtos yizu-tem-indi)f1)
 (write-line (rtos yizu2-indi)f1)
 (write-line (rtos wh-to-be) f2)
 (setq wh-to-be (+ wh-to-be 4)) )
 (progn
 (write-line (rtos 2) f1)
 (write-line (rtos yizu1-indi)f1)
 (write-line (rtos yizu-tem-indi)f1)
 (write-line (rtos wh-to-be) f2)
 (setq wh-to-be (+ wh-to-be 3))) )))))
######################condition1-1 over

######################condition1-2 start

 (setq diana (polar p12 (angle jiaodian p12) 1000))
 (setq ang4 (abs (- (angle px diana) (angle px py))))
 (if (> ang4 3.1415926)
 (setq ang4 (- 6.2831852 ang4 )))
 (if (> (distance diana p1) (* (sin ang4) (distance diana px)))
 (progn
 (setq dianb p12)
 (setq dianc (list (/ (+ (car diana) (car dianb)) 2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr diana) ))
 (setq juli1 (distance dianc p1))
 (setq ang3 (abs (- (angle px dianc) (angle px py))))
 (if (> ang3 3.1415926)
 (setq ang3 (- 6.2831852 ang3 )))
 (setq juli2 (* (distance dianc px) (sin ang3)))
 (setq jindu (abs (- juli1 juli2)))
 (setq repe-num 0)
 (while (and (> jindu err1) (< repe-num 200))
 (setq repe-num (1+ repe-num))
 (if (> juli1 juli2)
(progn
(setq diana dianc) )
(progn
(setq dianb dianc) ) )
 (setq dianc (list (/ (+ (car diana) (car dianb)) 2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
```

```
diana) ))
  (setq juli1 (distance dianc p1))
  (setq ang3 (abs (- (angle px dianc) (angle px
py))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq juli2 (* (distance dianc px) (sin ang3)))
  (setq jindu (abs (- juli1 juli2)))
(setq jiaodian dianc)

####newone

#tiaozhengjingdu
(setq test-po (polar inter1 (angle p9 inter1) (sqrt
(abs (- (* (distance inter1 jiaodian) (distance
inter1 jiaodian)) (* (distance jiaodian p1)
(distance jiaodian p1)))))))

(if (or (< (* (- (car test-po)(car px)) (- (car
test-po) (car py)) ) 0) (< (* (- (cadr
test-po)(cadr px)) (- (cadr test-po) (cadr py)) )
0))
  (progn
  (setq rp4 (- (distance jiaodian p1) err))
  (setq p4 jiaodian)
  (print "asdfsfdf")
  (setq k 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1) )
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1) ) )
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1)))
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1))))))))
  (setq k(1+ k)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member px yizu-tem) nil)
  (setq testzu 1) ) )
(if (and (/= yizu2-indi yizu-tem-indi) (/=
yizu1-indi yizu2-indi) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4)) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3))) ) ))) ) ))

####################condition1-2 over

##########################condition2-1
))
##########################condition2-1
############################

)) )
(progn
##################2p1l-pingxing
(if (and ( and (and (and (= (equal p11 px) nil)
(= (equal p11 py) nil)) (= (equal p1 px) nil)) (=
(equal p1 py) nil ) )
(= (member px yizu1) nil))
(progn
(setq p5 (list (/ (+ (car p1) (car p11)) 2) (/ (+
(cadr p1) (cadr p11)) 2) (caddr p1) ))
(setq p6 (polar p5 (+(angle p1 p11) (/
```

```
3.1415926 2)) 1000))
(setq jiaodian (inters px py p5 p6 nil))
(setq p9 jiaodian)
#tiaozhengjingdu
 (setq ang3 (abs (- (angle px p5) (angle px
py))))
 (if (> ang3 3.1415926)
 (setq ang3 (- 6.2831852 ang3 )) )
####newone
 (if (< (/ (distance p1 p11) 2) (* (sin ang3)
(distance p5 px)))
 (progn
 (setq diana jiaodian)
 (setq dianb p5)
 (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
 (setq juli1 (distance dianc p1))
 (setq ang3 (abs (- (angle px dianc) (angle px
py))))
 (if (> ang3 3.1415926)
 (setq ang3 (- 6.2831852 ang3 )) )
 (setq juli2 (* (distance dianc px) (sin ang3)))
 (setq jindu (abs (- juli1 juli2)))
 (setq repe-num 0)
 (while (and (> jindu err1) (< repe-num 200))
 (setq repe-num (1+ repe-num))
 (if (> juli1 juli2)
(progn
(setq diana dianc) )
(progn
(setq dianb dianc)) )
 (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
 (setq juli1 (distance dianc p1))
 (setq ang3 (abs (- (angle px dianc) (angle px
py))))
 (if (> ang3 3.1415926)
 (setq ang3 (- 6.2831852 ang3 )) )
 (setq juli2 (* (distance dianc px) (sin ang3)))
 (setq jindu (abs (- juli1 juli2))))
(setq jiaodian dianc)

####newone

#tiaozhengjingdu
(setq test-po p9)
(if (or (< (* (- (car test-po)(car px)) (- (car
test-po) (car py)) ) 0) (< (* (- (cadr
test-po)(cadr px)) (- (cadr test-po) (cadr py)) )
0))
 (progn
 (setq rp4 (- (distance jiaodian p1) err))
 (setq p4 jiaodian)
 (print "asdfsfdf")
 (setq k 0)
 (setq test1 0)
 (if (< rp4 min-r)
 (setq test1 1) )
 (while (and (< k entlen) (= test1 0) )
 (setq ent2 (ssname entall k))
 (setq ent3 (cdr (assoc 0 (entget ent2))))
 (if(= ent3 "LINE")
 (progn
 (setq px1 (cdr (assoc 10 (entget ent2 ))))
 (setq py1 (cdr (assoc 11 (entget ent2 ))))
 (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
 (if (> ang3 3.1415926)
 (setq ang3 (- 6.2831852 ang3 )))
 (setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
 (if (> ang4 3.1415926)
 (setq ang4 (- 6.2831852 ang4 )))
 (if (> ang3 (/ 3.1415926 2))
 (progn
(if (< (distance px1 p4) rp4)
(setq test1 1)))
 (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1)) )
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1) ))) ) ) ))
 (setq k(1+ k)) )
 (if (/= test1 1)
 (progn
 (setq num-cir (1+ num-cir))
 (command "circle" p4 rp4 "")
 (setq en (entlast))
 (setq ed (entget en))
 (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
 (entmod ed)
 (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
 (write-line (rtos rp4)f)
 (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
 (setq quanbuzu-tem (cdr quanbuzu-tem))
 (setq yizu-tem-indi (1+ yizu-tem-indi))
 (if (/= (member px yizu-tem) nil)
 (setq testzu 1) ) )
(if (and (/= yizu2-indi yizu-tem-indi) (/=
yizu1-indi yizu2-indi) )
(progn
 (write-line (rtos 3) f1)
```

```
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4)) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) ))))) )
######################condition1-1 over

######################condition1-2 start

######################condition1-2 over

  ))
############################
)
  (progn
#####################################
####################
(setq posi (- (length quanbuzu) 1))
(if (and ( and (and (and (= (equal p11 px) nil)
(= (equal p11 py) nil)) (= (equal p1 px) nil)) (=
(equal p1 py) nil ) )
  (and (and(member p1 (nth posi quanbuzu))
(member px (nth posi quanbuzu)) ) (member
p11 (nth posi quanbuzu)) ) )
  (progn

#################################men
(setq p5 (list (/ (+ (car p1) (car p11)) 2) (/ (+
(cadr p1) (cadr p11)) 2) (caddr p1) ))
(setq p6 (polar p5 (+(angle p1 p11) (/
3.1415926 2)) 1000))
(setq jiaodian (inters px py p5 p6 nil))
(setq p9 jiaodian)
(setq p10 (list (/ (+ (car p9) (car p11)) 2) (/ (+
(cadr p9) (cadr p11)) 2) (caddr p9) ))
#tiaozhengjingdu

(setq p12 (polar p10 (+(angle p9 p11) (/
3.1415926 2)) 1000))
(setq jiaodian (inters p5 p6 p10 p12 nil))

####newone

#tiaozhengjingdu
(setq test-po p9)
(if (or (< (* (- (car test-po)(car px)) (- (car
test-po) (car py)) ) 0) (< (* (- (cadr
test-po)(cadr px)) (- (cadr test-po) (cadr
py)) )0 ))
  (progn
  (setq rp4 (- (distance jiaodian p1) err))
  (setq p4 jiaodian)
  (print "asdfsfdf")
  (setq k 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1) ) )
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1) ))
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1))) ) ) ) ))
  (setq k(1+ k)))
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member px yizu-tem) nil)
  (setq testzu 1) ) )
  (write-line (rtos 2) f1)
```

```
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3))))) )
######################condition1-1 over

######################condition1-2 start

######################condition1-2 over


###################################men

  ) )

########################################
####################

  ))
###################2p1l-pingxing

) )))
(setq j (1+ j)))

# 2p1l

(print "2p lea")
(if (= (member p11 yizu1) nil)
  (progn
(setq p4 (list (/ (+ (car p1) (car p11)) 2) (/ (+
(cadr p1) (cadr p11)) 2) (caddr p1) ))
(setq rp4 (- (/ (distance p1 p11) 2) err))
(setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1) )
(setq k 0)
(while (and (< k entlen) (= test1 0) )
(setq ent2 (ssname entall k))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
(setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
(if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
(if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1)))
  (progn
(if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1) ) )
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1) ) )) ) ) ))
  (setq k (1+ k)) )
  (if (/= test1 1)
  (progn
  (command "circle" p4 rp4 "")
  (setq num-cir (1+ num-cir))
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)

  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )) ))

(setq asd-tem2 asd-tem1)
(setq asd-0-tem2 asd-0-tem1)
(setq asd-test1-tem2 asd-test1-tem1)
(setq num-asd2 (length asd-tem2))
(repeat num-asd2
(setq p111 (car asd-tem2))
(setq asd-tem2 (cdr asd-tem2))
(setq p000 (car asd-0-tem2))
(setq asd-0-tem2 (cdr asd-0-tem2))
(setq p222 (car asd-test1-tem2))
(setq asd-test1-tem2 (cdr asd-test1-tem2))
(setq p333 (car asd-test1-tem2))
(setq asd-test1-tem2 (cdr asd-test1-tem2))
  (print "3p lea")
(setq ang111 (abs (- (angle p111 p000) (angle
p111 p333))))
  (if (> ang111 3.1415926)
  (setq ang111 (- 6.2831852 ang111 )))
  (setq ang222 (abs (- (angle p111 p000) (angle
p111 p222))))
  (if (> ang222 3.1415926)
  (setq ang222 (- 6.2831852 ang222 )) )
  (setq jiaodu2 (+ang111 ang222 ))
  (if (and (> jiaodu2 (/ 3.1415926 2)) (=
(member p111 yizu1) nil) )
  (progn
  (setq k 0)
  (setq test1 0)
  (while (and (< k entlen) (= test1 0) )
  (setq ent2 (ssname entall k))
```

```
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (if (or (and (/= (inters p1 p111 px1 py1)
nil)(and (and (and (= (equal p111 px1) nil) (=
(equal p111 py1) nil)) (= (equal p1 px1) nil)) (=
(equal p1 py1) nil ) ))
(and (/= (inters p11 p111 px1 py1) nil)(and (and
(and (= (equal p111 px1) nil) (= (equal p111
py1) nil)) (= (equal p11 px1) nil)) (= (equal p11
py1) nil ) )))
  (setq test1 1) ) ))
(setq k (1+ k)) )
  (if (and (= test1 0)
(> (abs ( - (* (- (car p1) (car p11)) (- (cadr p1)
(cadr p111))) (* (- (cadr p1) (cadr p11)) (- (car
p1) (carp111))) )) 0.0001) )
(progn
(setq tem-po1 (list (/ (+ (car p1) (car p11)) 2) (/
(+ (cadr p1) (cadr p11)) 2) (caddr p1) ))
(setq tem-po2 (list (/ (+ (car p1) (car p111)) 2)
(/ (+ (cadr p1) (cadr p111)) 2) (caddr p1) ))
(setq p4 (inters tem-po1 (polar tem-po1 (+
(angle p1 p11) (/ 3.1415926 2)) 1) tem-po2
(polar tem-po2 (+ (angle p1 p111) (/ 3.1415926
2)) 1) nil))
(setq rp4 (- (distance p4 p1) err))
  (if (< rp4 min-r)
  (setq test1 1) )
(setq k 0)
(while (and (< k entlen) (= test1 0) )
(setq ent2 (ssname entall k))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1 p4) (angle px1
py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
(setq ang4 (abs (- (angle py1 p4) (angle py1
px1))))
(if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
(if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 p4) rp4)
(setq test1 1)) )
  (progn
(if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 p4) rp4)
(setq test1 1))
(progn
(if (< (* (distance p4 px1) (sin ang3)) rp4)
(setq test1 1)) ) ) ) )))
  (setq k (1+ k)))
  (if (/= test1 1)
  (progn
  (command "circle" p4 rp4 "")
  (setq num-cir (1+ num-cir))
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
#
  (setq quanbuzu-tem quanbuzu)
(setq testzu 0)
(setq yizu-tem-indi 0)
(while (and (= testzu 0) (setq yizu-tem (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu-tem-indi (1+ yizu-tem-indi))
  (if (/= (member p111 yizu-tem) nil)
  (setq testzu 1) ) )
(if (and (/= yizu2-indi yizu-tem-indi) (/=
yizu1-indi yizu2-indi) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4)))
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu-tem-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3))) )
#
  ) ))) )))) ))) ) )) )
############################

(setq indica 3)

(setq i 0)
(repeat entlen
(setq ent2 (ssname entall i))
(setq ent3 (entget ent2))
(setq ent4 (cdr(assoc 0 ent3)))
  (setq px (cdr (assoc 10 (entget ent2 ))))
  (setq py (cdr (assoc 11 (entget ent2 ))))
(setq quanbuzu-tem quanbuzu)
  (setq testzu 0)
  (setq yizu1-indi 0)
```

```
  (while (and (= testzu 0) (setq yizu1 (car quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu1-indi (1+ yizu1-indi))
  (if (/= (member px yizu1) nil)
  (setq testzu 1)))
  (setq j (+ 1 i))
  (repeat (- entlen (+ 1 i) )
(setq ent22 (ssname entall j))
(setq px1 (cdr (assoc 10 (entget ent22 ))))
(setq py1 (cdr (assoc 11 (entget ent22 ))))
(setq quanbuzu-tem quanbuzu)
  (setq testzu 0)
  (setq yizu2-indi 0)
  (while (and (= testzu 0) (setq yizu2 (car quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu2-indi (1+ yizu2-indi))
  (if (/= (member px1 yizu2) nil)
  (setq testzu 1) ))
(setq asd-tem asd)
(setq asd-0-tem asd-0)
(setq asd-test1-tem asd-test1)
(setq time 0)
(repeat num-asd
  (setq time (1+ time))
  (setq p1 (car asd-tem))
  (setq asd-tem (cdr asd-tem))
  (setq p0 (car asd-0-tem))
  (setq asd-0-tem (cdr asd-0-tem))
  (setq p2 (car asd-test1-tem))
  (setq asd-test1-tem (cdr asd-test1-tem))
  (setq p3 (car asd-test1-tem))
  (setq asd-test1-tem (cdr asd-test1-tem))
  (setq test11 0)
  (setq test10 0)
(setq ang1 (abs (- (angle p1 p0) (angle p1 p3))))
(if (> ang1 3.1415926)
(setq ang1 (- 6.2831852 ang1 )))
(setq ang2 (abs (- (angle p1 p0) (angle p1 p2))))
(if (> ang2 3.1415926)
(setq ang2 (- 6.2831852 ang2 )))
(setq jiaodu (+ang1 ang2 ))
(if (< jiaodu 3.1415926)
  (setq test11 1) )
(setq quanbuzu-tem quanbuzu)
  (setq testzu 0)
  (setq yizu3-indi 0)
  (while (and (= testzu 0) (setq yizu3 (car quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu3-indi (1+ yizu3-indi))
  (if (/= (member p1 yizu3) nil)
  (setq testzu 1) ) )

  (if (and (= yizu1-indi yizu2-indi) (= yizu1-indi yizu3-indi))
  (setq test11 1) )
  (if (or (equal p1 py1)
  (or(equal p1 px1)
  (or (equal p1 px) (equal p1 py)) ))
  (setq test11 1))
  (if (or (< (abs (- (* (- (car p1) (car px)) (- (cadr py) (cadr px))) (* (- (cadr p1) (cadr px)) (- (car py) (car px))) )) 0.001)
  (< (abs (- (* (- (car p1) (car px1)) (- (cadr py1) (cadr px1))) (* (- (cadr p1) (cadr px1)) (- (car py1) (car px1))) )) 0.001))
  (setq test11 1) )
(if(and (= test11 0) (< (abs (- (* (- (car py1) (car px1)) (- (cadr py) (cadr px))) (* (- (cadr py1) (cadr px1)) (- (car py) (car px)))) ) 0.001))
  (progn
##########parrel
  (setq ang3 (abs (- (angle px p1) (angle px py))))
(if (> ang3 3.1415926)
(setq ang3 (- 6.2831852 ang3 )))
  (setq ang33 ang3)
  (setq ang4 (abs (- (angle px1 p1) (angle px1 py1))))
(if (> ang4 3.1415926)
(setq ang4 (- 6.2831852 ang4 )) )
(setq ang44 ang4)
  (setq ang5 (abs (- (angle px1 px) (angle px1 py1))))
(if (> ang5 3.1415926)
(setq ang5 (- 6.2831852 ang5 )) )
(setq ang55 ang5)
  (setq chuiju1 (* (distance p1 px) (sin ang33)))
  (setq chuiju2 (* (distance p1 px1) (sin ang44)))
  (setq chuiju3 (* (distance px px1) (sin ang55)))
  (if (and (< chuiju1 chuiju3)(< chuiju2 chuiju3))
  (progn
  (setq angle1 (angle px py))
##########################diedaijiaozheng

  (setq angle2 (+ angle1 (/ 3.1415926 2)))
  (setq p7 (polar p1 angle2 100))
  (setq p8 (list (/ (+ (car px) (car px1)) 2) (/ (+ (cadr px) (cadr px1)) 2) (caddr px) ))
  (setq p9 (list (/ (+ (car px) (car py1)) 2) (/ (+ (cadr px) (cadr py1)) 2) (caddr px) ))
  (setq chadian (inters p1 p7 p8 p9 nil))
###########youlai

############################

  (setq diana (polar chadian (angle p9 p8) 1000))
  (if (> (distance diana p1)(/ chuiju3 2))
```

```
  (progn
  (setq dianb chadian)
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))
  (setq juli2 (/ chuiju3 2))
  (setq jindu (abs (- juli1 juli2)))
  (setq repe-num 0)
  (while (and (> jindu err1) (< repe-num 200))
  (setq repe-num (1+ repe-num))
  (if (> juli1 juli2)
(progn
(setq diana dianc) )
(progn
(setq dianb dianc)))
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))

  (setq juli2 (/ chuiju3 2))
  (setq jindu (abs (- juli1 juli2))))
(setq jiaodian-t dianc)

############################

#########################diedaijiaozheng

(if (< jindu err1)
  (progn
  (setq angle1 (+ (angle px py) (/ 3.1415926 2)))
  (setq angle2 (+ (angle px1 py1) (/ 3.1415926
2)))
  (setq p7 (polar jiaodian-t angle1 100))
  (setq p8 (polar jiaodian-t angle2 100))
  (setq luodian1 (inters jiaodian-t p7 px py nil))
  (setq luodian2 (inters jiaodian-t p8 px1 py1
nil))
(if (and
(or (< (* (- (car luodian1)(car px)) (- (car
luodian1) (car py)) ) 0) (< (* (- (cadr
luodian1)(cadr px)) (- (cadr luodian1) (cadr
py)) ) 0))
(or (< (* (- (car luodian2)(car px1)) (- (car
luodian2) (car py1)) ) 0) (< (* (- (cadr
luodian2)(cadr px1)) (- (cadr luodian2) (cadr
py1)) ) 0)))
  (progn
  (setq rp4 (- (distance jiaodian-t p1) err))
  (setq p4 jiaodian-t)
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1) ))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1)))
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1) ) ) ) )) ))
  (setq h (1+ h)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi))
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
```

```
  (setq wh-to-be (+ wh-to-be 4)) ) )))))))
#################2
  (setq jiaodian-t (polar jiaodian-t (angle jiaodian-t chadian) (* 2 (distance jiaodian-t chadian))))
  (setq angle1 (+ (angle px py) (/ 3.1415926 2)))
  (setq angle2 (+ (angle px1 py1) (/ 3.1415926 2)))
  (setq p7 (polar jiaodian-t angle1 100))
  (setq p8 (polar jiaodian-t angle2 100))
  (setq luodian1 (inters jiaodian-t p7 px py nil))
  (setq luodian2 (inters jiaodian-t p8 px1 py1 nil))
(if (and
(or (< (* (- (car luodian1)(car px)) (- (car luodian1) (car py)) ) 0) (< (* (- (cadr luodian1)(cadr px)) (- (cadr luodian1) (cadr py)) ) 0))
(or (< (* (- (car luodian2)(car px1)) (- (car luodian2) (car py1)) ) 0) (< (* (- (cadr luodian2)(cadr px1)) (- (cadr luodian2) (cadr py1)) ) 0)))
  (progn
  (setq rp4 (- (distance jiaodian-t p1) err))
  (setq p4 jiaodian-t)
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1) )
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (setq ang4 (abs (- (angle py1111 p4) (angle py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1)) )
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1) ))
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1)))))) ))
  (setq h (1+ h)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr p4))) (assoc 10 ed) ed) )
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos (cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)

  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi yizu3-indi) )
  (= yizu2-indi yizu3-indi) )
  (prong
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)))
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4)))))) ))
###########youlai

  ))))
##########parrel
  )
  (progn
  (if (= test11 0)
  (progn
  (setq testjiao (inters px py px1 py1 nil))
################################
  (setq test2 1)
(if(or
  (or (equal px px1) (equal px py1))
  (or (equal py px1) (equal py py1)))
  (progn
(if (equal px px1)
  (progn
  (setq bian1 py)
  (setq bian2 py1) ) )
(if (equal px py1)
  (progn
  (setq bian1 py)
  (setq bian2 px1) ))
(if (equal py px1)
```

```
  (progn
  (setq bian1 px)
  (setq bian2 py1) ) )
(if (equal py py1)
  (progn
  (setq bian1 px)
  (setq bian2 px1))))
(progn
(if (or
  (or (< (* (- (car testjiao)(car px)) (- (car testjiao) (car py)) ) 0) (< (* (- (cadr testjiao)(cadr px)) (- (cadr testjiao) (cadr py)) ) 0))
  (or (< (* (- (car testjiao)(car px1)) (- (car testjiao) (car py1)) ) 0) (< (* (- (cadr testjiao)(cadr px1)) (- (cadr testjiao) (cadr py1)) ) 0)))
  (progn
  (print "jinle2")
  (if (or (< (* (- (car testjiao)(car px)) (- (car testjiao) (car py)) ) 0) (< (* (- (cadr testjiao)(cadr px)) (- (cadr testjiao) (cadr py)) ) 0))
  (progn
  (setq bian2 px1)
  (setq ang3 (abs (- (angle testjiao p1) (angle testjiao px))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle testjiao p1) (angle testjiao px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
(setq ang (+ ang3 ang4))
(setq ang3 (abs (- (angle testjiao px) (angle testjiao px1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (if (> (abs (- ang ang3)) 0.001)
  (setq bian1 py)
  (setq bian1 px)) )
  (progn
  (setq bian1 px)
  (setq ang3 (abs (- (angle testjiao p1) (angle testjiao px))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (setq ang4 (abs (- (angle testjiao p1) (angle testjiao px1))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
(setq ang (+ ang3 ang4))
(setq ang3 (abs (- (angle testjiao px) (angle testjiao px1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (if (> (abs (- ang ang3)) 0.001)
  (setq bian2 py1)
  (setq bian2 px1)) ) ) )
  (progn
  (print "jinle3")
  (setq bian1 px)
  (setq bian2 px1)
  (if (equal testjiao px)
  (progn
(setq bian1 py)
(setq bian2 px1)))
  (if (equal testjiao py)
  (progn
(setq bian1 px)
(setq bian2 px1) ) )
  (if (equal testjiao px1)
  (progn
(setq bian1 px)
(setq bian2 py1) ) )
  (if (equal testjiao py1)
  (progn
(setq bian1 px)
(setq bian2 px1) ) ))) ) )
  (setq ang3 (abs (- (angle testjiao p1) (angle testjiao bian1))))
(if (> ang3 3.1415926)
(setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle testjiao p1) (angle testjiao bian2))))
(if (> ang4 3.1415926)
(setq ang4 (- 6.2831852 ang4 )) )
  (setq ang (+ ang3 ang4))
  (setq ang3 (abs (- (angle testjiao bian2) (angle testjiao bian1))))
(if (> ang3 3.1415926)
(setq ang3 (- 6.2831852 ang3 )) )
  (if (> (abs (- ang ang3)) 0.001)
(setq test10 1) )
(setq ang33 ang3)
  (if (= test10 0)
  (progn
  (write-line (strcat "(" "jinla"")") f5)
  (write-line (strcat "(" (rtos (car px)) " " (rtos (cadr px)) " " (rtos (caddr px)) ")") f5)
  (write-line (strcat "(" (rtos (car py)) " " (rtos (cadr py)) " " (rtos (caddr py)) ")") f5)
  (write-line (strcat "(" (rtos (car px1)) " " (rtos (cadr px1)) " " (rtos (caddr px1)) ")") f5)
  (write-line (strcat "(" (rtos (car py1)) " " (rtos (cadr py1)) " " (rtos (caddr py1)) ")") f5)
  (write-line (strcat "(" (rtos (car p1)) " " (rtos (cadr p1)) " " (rtos (caddr p1)) ")") f5)
  (write-line (strcat "(" (rtos (car bian1)) " " (rtos (cadr bian1)) " " (rtos (caddr bian1)) ")") f5)
  (write-line (strcat "(" (rtos (car bian2)) " " (rtos (cadr bian2)) " " (rtos (caddr bian2)) ")") f5)
```

```
  (print "jinla")
  (print px)
  (print py)
  (print px1)
  (print py1)
  (print p1)
  (print bian1)
  (print bian2)
  (print (equal bian1 px))
  (print (equal bian1 py))
  (print (equal bian2 px1))
  (print (equal bian2 py1))
  (setq angle1 (/ (+ (angle testjiao bian1) (angle
testjiao bian2)) 2))
  (setq testjiao1 (polar testjiao angle1 100))
  (setq p5 (list (/ (+ (car testjiao) (car p1)) 2) (/
(+ (cadr testjiao) (cadr p1)) 2) (caddr p1) ))
  (setq angle3 (+ (angle testjiao p1) (/
3.1415926 2)))
  (setq p6 (polar p5 angle3 100))
  (setq jiaodian-t (inters p5 p6 testjiao testjiao1
nil))
##########################diedaijiaozheng

  (setq angle2 (+ angle1 (/ 3.1415926 2)))
  (setq p7 (polar p1 angle2 100))
  (setq chadian (inters p1 p7 testjiao jiaodian-t
nil))
  (if (> (* (distance chadian testjiao) (sin (/
ang33 2))) (distance chadian p1))
(progn
#################

  (setq jiaodian-t chadian)
  (setq jiaodian-t1 testjiao)
  (setq diana jiaodian-t)
  (setq dianb jiaodian-t1)
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))
  (setq juli2 (* (distance dianc testjiao) (sin (/
ang33 2))))
  (setq jindu (abs (- juli1 juli2)))
  (setq repe-num 0)
  (while (and (> jindu err1) (< repe-num 200))
  (setq repe-num (1+ repe-num))

  (if (> juli1 juli2)
(progn
(setq dianb dianc) )
(progn
(setq diana dianc) ) )
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))
  (setq juli2 (* (distance dianc testjiao) (sin (/
ang33 2))))
  (setq jindu (abs (- juli1 juli2))))
(setq jiaodian-t dianc)

#################

##########################diedaijiaozheng

  (setq angle1 (+ (angle testjiao bian1) (/
3.1415926 2)))
  (setq angle2 (+ (angle testjiao bian2) (/
3.1415926 2)))
  (setq p7 (polar jiaodian-t angle1 100))
  (setq p8 (polar jiaodian-t angle2 100))
  (setq luodian1 (inters jiaodian-t p7 testjiao
bian1 nil))
  (setq luodian2 (inters jiaodian-t p8 testjiao
bian2 nil))
(if (and
(or (< (* (- (car luodian1)(car px)) (- (car
luodian1) (car py)) ) 0) (< (* (- (cadr
luodian1)(cadr px)) (- (cadr luodian1) (cadr
py)) ) 0))
(or (< (* (- (car luodian2)(car px1)) (- (car
luodian2) (car py1)) ) 0) (< (* (- (cadr
luodian2)(cadr px1)) (- (cadr luodian2) (cadr
py1)) ) 0)))
  (progn
  (setq rp4 (- (distance jiaodian-t p1) err))
  (setq p4 jiaodian-t)
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1) )
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1) ))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
```

```
(if (< (distance py1111 p4) rp4)
(setq test1 1)) )
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1) ) ) )) )))
  (setq h (1+ h)))
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4))) ) ))))
################2
  (setq angle1 (/ (+ (angle testjiao bian1) (angle
testjiao bian2)) 2))
  (print "youjinla")
  (setq y (distance chadian p1))
  (setq y1 (* (/ (sin (/ ang33 2)) 2) (/ (sin (/
ang33 2)) 2)))
  (setq y2 (/ (* y y) (- 1 y1)))
  (setq y3 (sqrt (- y2 (* y y))))
  (setq jiaodian-t (polar chadian (angle testjiao
chadian) y3))
  (setq jiaodian-t1 (polar chadian (angle testjiao
chadian) 1000))
(if (> (distance jiaodian-t1 p1) (* (distance
jiaodian-t1 testjiao) (sin (/ ang33 2))))
(progn
  (setq diana jiaodian-t)
  (setq dianb jiaodian-t1)
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))
  (setq juli2 (* (distance dianc testjiao) (sin (/
ang33 2))))
  (setq jindu (abs (- juli1 juli2)))
  (setq repe-num 0)
  (while (and (> jindu err1) (< repe-num 200))
  (setq repe-num (1+ repe-num))
  (if (> juli1 juli2)
(progn
(setq dianb dianc) )
(progn
(setq diana dianc)) )
  (setq dianc (list (/ (+ (car diana) (car dianb))
2) (/ (+ (cadr diana) (cadr dianb)) 2) (caddr
diana) ))
  (setq juli1 (distance dianc p1))
  (setq juli2 (* (distance dianc testjiao) (sin (/
ang33 2))))
  (setq jindu (abs (- juli1 juli2))))
(setq jiaodian-t dianc)
##########################diedaijiaozheng
  (setq angle1 (+ (angle testjiao bian1) (/
3.1415926 2)))
  (setq angle2 (+ (angle testjiao bian2) (/
3.1415926 2)))
  (setq p7 (polar jiaodian-t angle1 100))
  (setq p8 (polar jiaodian-t angle2 100))
  (setq luodian1 (inters jiaodian-t p7 testjiao
bian1 nil))
  (setq luodian2 (inters jiaodian-t p8 testjiao
bian2 nil))
(if (and
(or (< (* (- (car luodian1)(car px)) (- (car
luodian1) (car py)) ) 0) (< (* (- (cadr
luodian1)(cadr px)) (- (cadr luodian1) (cadr
py)) ) 0))
(or (< (* (- (car luodian2)(car px1)) (- (car
luodian2) (car py1)) ) 0) (< (* (- (cadr
luodian2)(cadr px1)) (- (cadr luodian2) (cadr
py1)) ) 0)))
  (progn
  (setq rp4 (- (distance jiaodian-t p1) err))
  (setq p4 jiaodian-t)
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
```

```
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1)) )
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1) ) )
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1)) ) )) ) ))
  (setq h (1+ h)))
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4))) )))))

################2

  )) )))) )))
#######################################
```

```
2l1dian jieshu

(setq k (+ 1 j))
(repeat (- entlen (+ 1 j) )
(setq ent222 (ssname entall k))
(setq px11 (cdr (assoc 10 (entget ent222 ))))
(setq py11 (cdr (assoc 11 (entget ent222 ))))
(setq quanbuzu-tem quanbuzu)
  (setq testzu 0)
  (setq yizu3-indi 0)
  (while (and (= testzu 0) (setq yizu3 (car
quanbuzu-tem)) )
  (setq quanbuzu-tem (cdr quanbuzu-tem))
  (setq yizu3-indi (1+ yizu3-indi))
  (if (/= (member px11 yizu3) nil)
  (setq testzu 1)))

#######################################
####3l

  (setq test1 0)
  (setq test2 0)
  (if (and (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi))
  (setq test1 1))
  (if
  (and
  (< (abs (- (* (- (car py1) (car px1)) (- (cadr py)
(cadr px))) (* (- (cadr py1) (cadr px1)) (- (car
py) (car px))))) 0.00001)
  (< (abs (- (* (- (car py1) (car px1)) (- (cadr
py11) (cadr px11))) (* (- (cadr py1) (cadr px1))
(- (car py11) (car px11))))) ) 0.00001))
  (progn
  (setq test1 1) )
  (progn
  (if (< (abs (- (* (- (car py1) (car px1)) (- (cadr
py) (cadr px))) (* (- (cadr py1) (cadr px1)) (-
(car py) (car px))))) 0.00001)
(progn
  (setq q1 px)
  (setq q2 py)
  (setq q3 px1)
  (setq q4 py1)
  (setq q5 px11)
  (setq q6 py11)
  (setq test2 1))
(progn
(if ( < (abs (- (* (- (car py1) (car px1)) (- (cadr
py11) (cadr px11))) (* (- (cadr py1) (cadr px1))
(- (car py11) (car px11))))) 0.00001)
(progn
(setq q1 px11)
(setq q2 py11)
(setq q3 px1)
(setq q4 py1)
(setq q5 px)
```

```
(setq q6 py)
(setq test2 1) )
(progn
  (if (< (abs (- (* (- (car py) (car px)) (- (cadr
py11) (cadr px11))) (* (- (cadr py) (cadr px)) (-
(car py11) (car px11))))) 0.00001)
(progn
  (setq q1 px11)
  (setq q2 py11)
  (setq q3 px)
  (setq q4 py)
  (setq q5 px1)
  (setq q6 py1)
  (setq test2 1) )) ) ) ) )) )
(print yizu1-indi)
(print yizu2-indi)
(print yizu3-indi)
(print test1)
(if (= test1 0)
  (progn
(if (= test2 1)
  (progn
  (setq jiaodian1 (inters q1 q2 q5 q6 nil))
  (setq jiaodian2 (inters q3 q4 q5 q6 nil))
(setq q7 (list (/ (+ (car q1) (car q3)) 2) (/ (+
(cadr q1) (cadr q3)) 2) (caddr q3) ))
(setq q8 (list (/ (+ (car q1) (car q4)) 2) (/ (+
(cadr q1) (cadr q4)) 2) (caddr q2) ))
(setq angle1 (/ (+ (angle q1 q2) (angle q5 q6))
2))
(setq angle2 (+ angle1 (/ 3.1415926 2)))
(setq q9 (polar jiaodian1 angle1 100))
(setq q10 (polar jiaodian1 angle2 100))
(setq center1 (inters jiaodian1 q9 q7 q8 nil))
(setq center2 (inters jiaodian1 q10 q7 q8 nil))
  (setq ang (abs (- (angle jiaodian1 center1)
(angle q1 q2))))
  (if (> ang 3.1415926)
  (setq ang (- 6.2831852 ang)) )
(setq rp4 (* (distance center1 jiaodian1) (sin
ang) ) )

####################################center
er1
(setq ang (+ (angle q1 q2) (/ 3.1415926 2)))
(setq angpo (polar center1 ang 100))
(setq test-po1 (inters angpo center1 q1 q2 nil))
(setq ang (+ (angle q3 q4) (/ 3.1415926 2)))
(setq angpo (polar center1 ang 100))
(setq test-po2 (inters angpo center1 q3 q4 nil))
(setq ang (+ (angle q5 q6) (/ 3.1415926 2)))
(setq angpo (polar center1 ang 100))
(setq test-po3 (inters angpo center1 q5 q6 nil))
(if(and
  (and
  (or (< (* (- (car test-po1)(car q1)) (- (car
test-po1) (car q2)) ) 0) (< (* (- (cadr
test-po1)(cadr q1)) (- (cadr test-po1) (cadr
q2)) ) 0))
  (or (< (* (- (car test-po2)(car q3)) (- (car
test-po2) (car q4)) ) 0) (< (* (- (cadr
test-po2)(cadr q3)) (- (cadr test-po2) (cadr
q4)) ) 0))
  )
  (or (< (* (- (car test-po3)(car q5)) (- (car
test-po3) (car q6)) ) 0) (< (* (- (cadr
test-po3)(cadr q5)) (- (cadr test-po3) (cadr
q6)) ) 0)) )
  (progn
  (setq p4 center1)
  (setq rp4 (- rp4 err))
  (print "asdfsfdf")
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1) ) )
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1)))
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1) )) ) ) ))
  (setq h (1+ h)))
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
```

```
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1))
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3))
)
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4))))))))
################################center1

################################center2
(setq ang (+ (angle q1 q2) (/ 3.1415926 2)))
(setq angpo (polar center2 ang 100))
(setq test-po1 (inters angpo center2 q1 q2 nil))
(setq ang (+ (angle q3 q4) (/ 3.1415926 2)))
(setq angpo (polar center2 ang 100))
(setq test-po2 (inters angpo center2 q3 q4 nil))
(setq ang (+ (angle q5 q6) (/ 3.1415926 2)))
(setq angpo (polar center2 ang 100))
(setq test-po3 (inters angpo center2 q5 q6 nil))
(if(and
  (and
  (or (< (* (- (car test-po1)(car q1)) (- (car
test-po1) (car q2)) ) 0) (< (* (- (cadr
test-po1)(cadr q1)) (- (cadr test-po1) (cadr
q2)) ) 0))
  (or (< (* (- (car test-po2)(car q3)) (- (car
test-po2) (car q4)) ) 0) (< (* (- (cadr
test-po2)(cadr q3)) (- (cadr test-po2) (cadr
q4)) ) 0)))
  (or (< (* (- (car test-po3)(car q5)) (- (car
test-po3) (car q6)) ) 0) (< (* (- (cadr
test-po3)(cadr q5)) (- (cadr test-po3) (cadr
q6)) ) 0)))
  (progn
  (setq p4 center2)
  (setq rp4 (- rp4 err))
  (print "asdfsfdf")
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1) )
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1) ))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1) ) )
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1) ) ) ) )) ))
  (setq h (1+ h)))
(if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1))
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)))
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
```

```
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4)))) ))))
##############################center2
  )
  (progn
##############################3unparre
l
  (setq q1 px11)
  (setq q2 py11)
  (setq q3 px)
  (setq q4 py)
  (setq q5 px1)
  (setq q6 py1)
  (setq jiaodian1 (inters q1 q2 q5 q6 nil))
  (setq jiaodian2 (inters q3 q4 q5 q6 nil))
(setq angle1 (/ (+ (angle q1 q2) (angle q5 q6))
2))
(setq angle2 (+ angle1 (/ 3.1415926 2)))
(setq angle3 (/ (+ (angle q3 q4) (angle q5 q6))
2))
(setq angle4 (+ angle3 (/ 3.1415926 2)))
(setq q9 (polar jiaodian1 angle1 100))
(setq q10 (polar jiaodian1 angle2 100))
(setq q11 (polar jiaodian2 angle3 100))
(setq q12 (polar jiaodian2 angle4 100))
(setq center1 (inters jiaodian1 q9 jiaodian2 q11
nil))
(setq center2 (inters jiaodian1 q9 jiaodian2 q12
nil))
(setq center3 (inters jiaodian1 q10 jiaodian2
q11 nil))
(setq center4 (inters jiaodian1 q10 jiaodian2
q12 nil))
  (setq ang (abs (- (angle jiaodian1 center1)
(angle q1 q2))))
  (if (> ang 3.1415926)
  (setq ang (- 6.2831852 ang)) )
  (setq r1 (* (distance center1 jiaodian1) (sin
ang) ) )
  (setq ang (abs (- (angle jiaodian1 center2)
(angle q1 q2))))
  (if (> ang 3.1415926)
  (setq ang (- 6.2831852 ang)) )
  (setq r2 (* (distance center2 jiaodian1) (sin
ang) ) )
  (setq ang (abs (- (angle jiaodian1 center3)
(angle q1 q2))))
  (if (> ang 3.1415926)
  (setq ang (- 6.2831852 ang)) )
  (setq r3 (* (distance center3 jiaodian1) (sin
ang) ) )
  (setq ang (abs (- (angle jiaodian1 center4)
(angle q1 q2))))
  (if (> ang 3.1415926)
  (setq ang (- 6.2831852 ang)) )
  (setq r4 (* (distance center4 jiaodian1) (sin
ang) ) )

####################center1
(setq ang (+ (angle q1 q2) (/ 3.1415926 2)))
(setq angpo (polar center1 ang 100))
(setq test-po1 (inters angpo center1 q1 q2 nil))
(setq ang (+ (angle q3 q4) (/ 3.1415926 2)))
(setq angpo (polar center1 ang 100))
(setq test-po2 (inters angpo center1 q3 q4 nil))
(setq ang (+ (angle q5 q6) (/ 3.1415926 2)))
(setq angpo (polar center1 ang 100))
(setq test-po3 (inters angpo center1 q5 q6 nil))
(if(and
  (and
  (or (< (* (- (car test-po1)(car q1)) (- (car
test-po1) (car q2)) ) 0) (< (* (- (cadr
test-po1)(cadr q1)) (- (cadr test-po1) (cadr
q2)) ) 0))
  (or (< (* (- (car test-po2)(car q3)) (- (car
test-po2) (car q4)) ) 0) (< (* (- (cadr
test-po2)(cadr q3)) (- (cadr test-po2) (cadr
q4)) ) 0)))
  (or (< (* (- (car test-po3)(car q5)) (- (car
test-po3) (car q6)) ) 0) (< (* (- (cadr
test-po3)(cadr q5)) (- (cadr test-po3) (cadr
q6)) ) 0)) )
  (progn
  (setq p4 center1)
  (setq rp4 (- r1 err))
  (print "asdfsfdf")
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1) ))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
```

```
(setq test1 1) ))
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1)) )) ) )))
  (setq h (1+ h)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)))
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)

  (setq wh-to-be (+ wh-to-be 4))) ))) ))

####################center1

######################center2

(setq ang (+ (angle q1 q2) (/ 3.1415926 2)))
(setq angpo (polar center2 ang 100))
(setq test-po1 (inters angpo center2 q1 q2 nil))
(setq ang (+ (angle q3 q4) (/ 3.1415926 2)))
(setq angpo (polar center2 ang 100))
(setq test-po2 (inters angpo center2 q3 q4 nil))
(setq ang (+ (angle q5 q6) (/ 3.1415926 2)))
(setq angpo (polar center2 ang 100))
(setq test-po3 (inters angpo center2 q5 q6 nil))
(if(and
  (and
  (or (< (* (- (car test-po1)(car q1)) (- (car
test-po1) (car q2)) ) 0) (< (* (- (cadr
test-po1)(cadr q1)) (- (cadr test-po1) (cadr
q2)) ) 0))
  (or (< (* (- (car test-po2)(car q3)) (- (car
test-po2) (car q4)) ) 0) (< (* (- (cadr
test-po2)(cadr q3)) (- (cadr test-po2) (cadr
q4)) ) 0)))
  (or (< (* (- (car test-po3)(car q5)) (- (car
test-po3) (car q6)) ) 0) (< (* (- (cadr
test-po3)(cadr q5)) (- (cadr test-po3) (cadr
q6)) ) 0)))
  (progn
  (setq p4 center2)
  (setq rp4 (- r2 err))
  (print "asdfsfdf")
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1) )
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1)))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1) ))
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1))))) )))
  (setq h (1+ h)) )
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
```

```
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi))
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4)) )) )) ) )
######################center2

########################center3

(setq ang (+ (angle q1 q2) (/ 3.1415926 2)))
(setq angpo (polar center3 ang 100))
(setq test-po1 (inters angpo center3 q1 q2 nil))
(setq ang (+ (angle q3 q4) (/ 3.1415926 2)))
(setq angpo (polar center3 ang 100))
(setq test-po2 (inters angpo center3 q3 q4 nil))
(setq ang (+ (angle q5 q6) (/ 3.1415926 2)))
(setq angpo (polar center3 ang 100))
(setq test-po3 (inters angpo center3 q5 q6 nil))
(if(and
  (and
  (or (< (* (- (car test-po1)(car q1)) (- (car
test-po1) (car q2)) ) 0) (< (* (- (cadr
test-po1)(cadr q1)) (- (cadr test-po1) (cadr
q2)) ) 0))
  (or (< (* (- (car test-po2)(car q3)) (- (car
test-po2) (car q4)) ) 0) (< (* (- (cadr
test-po2)(cadr q3)) (- (cadr test-po2) (cadr
q4)) ) 0)) )
  (or (< (* (- (car test-po3)(car q5)) (- (car
test-po3) (car q6)) ) 0) (< (* (- (cadr
test-po3)(cadr q5)) (- (cadr test-po3) (cadr
q6)) ) 0)) )
  (progn
  (setq p4 center3)
  (setq rp4 (- r3 err))
  (print "asdfsfdf")
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )) )
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1)) )
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1)))
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1) ) ) ) ) ) ))
  (setq h (1+ h)) )
(if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed) )
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4) f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi) )
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1) )
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
```

```
  (setq wh-to-be (+ wh-to-be 4)) ))))))

##########################center3

##########################center4
(setq ang (+ (angle q1 q2) (/ 3.1415926 2)))
(setq angpo (polar center4 ang 100))
(setq test-po1 (inters angpo center4 q1 q2 nil))
(setq ang (+ (angle q3 q4) (/ 3.1415926 2)))
(setq angpo (polar center4 ang 100))
(setq test-po2 (inters angpo center4 q3 q4 nil))
(setq ang (+ (angle q5 q6) (/ 3.1415926 2)))
(setq angpo (polar center4 ang 100))
(setq test-po3 (inters angpo center4 q5 q6 nil))
(if(and
  (and
  (or (< (* (- (car test-po1)(car q1)) (- (car
test-po1) (car q2)) ) 0) (< (* (- (cadr
test-po1)(cadr q1)) (- (cadr test-po1) (cadr
q2)) ) 0))
  (or (< (* (- (car test-po2)(car q3)) (- (car
test-po2) (car q4)) ) 0) (< (* (- (cadr
test-po2)(cadr q3)) (- (cadr test-po2) (cadr
q4)) ) 0)))
  (or (< (* (- (car test-po3)(car q5)) (- (car
test-po3) (car q6)) ) 0) (< (* (- (cadr
test-po3)(cadr q5)) (- (cadr test-po3) (cadr
q6)) ) 0)) )
  (progn
  (setq p4 center4)
  (setq rp4 (- r4 err))
  (print "asdfsfdf")
  (setq h 0)
  (setq test1 0)
  (if (< rp4 min-r)
  (setq test1 1))
  (while (and (< h entlen) (= test1 0) )
  (setq ent2 (ssname entall h))
  (setq ent3 (cdr (assoc 0 (entget ent2))))
  (if(= ent3 "LINE")
  (progn
  (setq px1111 (cdr (assoc 10 (entget ent2 ))))
  (setq py1111 (cdr (assoc 11 (entget ent2 ))))
  (setq ang3 (abs (- (angle px1111 p4) (angle
px1111 py1111))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )) )
  (setq ang4 (abs (- (angle py1111 p4) (angle
py1111 px1111))))
  (if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
  (if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1111 p4) rp4)
(setq test1 1) ))
  (progn
( if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1111 p4) rp4)
(setq test1 1) ))
(progn
(if (< (* (distance p4 px1111) (sin ang3)) rp4)
(setq test1 1))) ) ) ) ))
  (setq h (1+ h)))
  (if (/= test1 1)
  (progn
  (setq num-cir (1+ num-cir))
  (command "circle" p4 rp4 "")
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr
p4))) (assoc 10 ed) ed))
  (entmod ed)
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (rtos rp4)f)
  (if (or
  (or (= yizu1-indi yizu2-indi) (= yizu1-indi
yizu3-indi) )
  (= yizu2-indi yizu3-indi))
  (progn
  (write-line (rtos 2) f1)
  (write-line (rtos yizu1-indi)f1)
(if (/= yizu1-indi yizu2-indi)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1))
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 3)) )
(progn
  (write-line (rtos 3) f1)
  (write-line (rtos yizu1-indi)f1)
  (write-line (rtos yizu2-indi)f1)
  (write-line (rtos yizu3-indi)f1)
  (write-line (rtos wh-to-be) f2)
  (setq wh-to-be (+ wh-to-be 4) ) ))) ))
##########################center4
##############################3unparre
l
  ) )))
#######################################
####3l

(setq k (1+ k)) )
(setq j (1+ j)) )
(setq i (1+ i)) )

##########################

  (setq ii (1+ ii)) )
  (close f)
  (close f1)
  (close f2)
```

```
(close f3)
(close f4)
(close f5))
```

6. Auto CAD programming 2 – Connect circulation routes

```
(Defun C:huaxian()
(setq dire (getstring "Please input the directory you want to read the circle file") )
(setq min-rr(/ (getreal "Dear miss MA, it is about to draw the circles. Please input an integer to indicate the minimum radius you require: ") 10) )
(setq asd-cir nil)
(setq asd-cir1 nil)
(setq asd-cir2 nil)
(setq asd-cir3 nil)
(setq quanbu-line nil)
(setq f (open "test.txt" "w"))
  (close f)
  (setq f (open "test1.txt" "w"))
  (close f)
  (setq f (open "test2.txt" "w"))
  (close f)
  (setq f (open "test3.txt" "w"))
  (close f)
  (setq f (open "test4.txt" "w"))
  (close f)
  (setq f (open (strcat dire "line.csv") "w"))
  (close f)
(setq asd1 nil)
(setq asd-lianjie nil)
(setq entall (ssget "X"))
(setq entlen (sslength entall))。。
(setq f (open "line.txt" "w"))
(close f)
(setq cao1 (list 232432 233 4354) )
(setq cao2 34534)
(setq cao3 (list 2312 35434 23132))
(setq cao4 90523)
(setq cao5 78723)
(setq cao6 66623)
(setq f (open (strcat dire "circle.txt") "r"))
(while (setq p4 (read-line f))
(setq p4 (read p4))
(setq rp4 (read-line f))
(setq rp4 (read rp4))
(setq asd-cir (cons p4 (cons rp4 asd-cir))))
(close f)
(setq f (open (strcat dire "circle1.txt") "r"))
(while (setq num (read-line f))
(setq num (read num))
(setq asd-cir3 (cons num asd-cir3)))
  (close f)
  (setq i 0)
  (repeat (length asd-cir3)
  (setq asd-cir1 (cons (nth i asd-cir3) asd-cir1))
  (setq i (1+ i)))
(setq f (open (strcat dire "circle2.txt") "r"))
(while (setq num (read-line f))
(setq num (read num))
(setq asd-cir2 (cons num asd-cir2)))
(close f)
(setq test 0)
(setq asd-cir-tem asd-cir)
(setq asd-cir2-tem asd-cir2)
(setq p4 (car asd-cir-tem))
(setq asd-cir-tem (cdr asd-cir-tem))
(setq rp4 (car asd-cir-tem))
(setq asd1 (cons p4 asd1))
(setq asd-num (length asd-cir))
(setq li 0)
(while (< li (/ asd-num 2))
  (setq li (1+ li))
  (setq p4 (nth (* 2 (- li 1)) asd-cir))
  (setq rp4 (nth (+ (* 2 (- li 1)) 1) asd-cir))
  (setq p4-num (nth (- li 1) asd-cir2))
  (setq test 1)
  (setq asd-cir-tem asd-cir)
  (setq asd-cir2-tem asd-cir2)
  (setq asd-p4 nil)
(setq f (open "test3.txt" "a"))
(write-line (strcat "(" (rtos (car p4)) " " (rtos (cadr p4)) " " (rtos (caddr p4)) ")") f)
(write-line (rtos 23424234234) f)
(close f)
(setq f (open "test4.txt" "a"))
(write-line (strcat "(" (rtos (car p4)) " " (rtos (cadr p4)) " " (rtos (caddr p4)) ")") f)
(write-line (rtos 23424234234) f)
(close f)
  (repeat (/ asd-num 2)
(setq p5 (car asd-cir-tem))
(setq asd-cir-tem (cdr asd-cir-tem))
(setq rp5 (car asd-cir-tem))
(setq asd-cir-tem (cdr asd-cir-tem))
(setq p5-num (car asd-cir2-tem))
(setq asd-cir2-tem (cdr asd-cir2-tem))
(setq test1 0)
(setq asd-p4-yizu nil)
(setq angle1 (+ (angle p4 p5) (/ 3.1415926 2)))
(setq angle2 (- (angle p4 p5) (/ 3.1415926 2)))
(setq p4x (polar p4 angle1 (* 0.6 rp4)))
(setq p4y (polar p4 angle2 (* 0.6 rp4)))
(setq p5x (polar p5 angle1 (* 0.6 rp5)))
(setq p5y (polar p5 angle2 (* 0.6 rp5)))
(setq p4x1 (polar p4 angle1 (* 0.3 rp4)))
(setq p4y1 (polar p4 angle2 (* 0.3 rp4)))
(setq p5x1 (polar p5 angle1 (* 0.3 rp5)))
(setq p5y1 (polar p5 angle2 (* 0.3 rp5)))
(setq j 0)
(if (or (< rp4 min-rr) (< rp5 min-rr))
  (setq test1 1))
(if (= (nth (+ p5-num 1) asd-cir1) (nth (+ p5-num 2) asd-cir1))
  (setq test1 1))
(if (= (nth p4-num asd-cir1) 2)
```

```
(progn
(if (= (nth p5-num asd-cir1) 2)
(progn
  (if(and
  (or (= (nth (+ p4-num 1) asd-cir1) (nth (+ p5-num 1) asd-cir1))
  (= (nth (+ p4-num 1) asd-cir1) (nth (+ p5-num 2) asd-cir1)))
  (or (= (nth (+ p4-num 2) asd-cir1) (nth (+ p5-num 1) asd-cir1))
  (= (nth (+ p4-num 2) asd-cir1) (nth (+ p5-num 2) asd-cir1))))
()
(setq test1 1)))
(progn
(setq test1 1))))
(progn
(setq p4-yizu1 nil)
(setq p4-yizu1 (cons (nth (+ p4-num 1) asd-cir1) p4-yizu1))
(setq p4-yizu1 (cons (nth (+ p4-num 2) asd-cir1) p4-yizu1))
(setq p4-yizu2 nil)
(setq p4-yizu2 (cons (nth (+ p4-num 1) asd-cir1) p4-yizu2))
(setq p4-yizu2 (cons (nth (+ p4-num 3) asd-cir1) p4-yizu2))
(setq p4-yizu3 nil)
(setq p4-yizu3 (cons (nth (+ p4-num 3) asd-cir1) p4-yizu3))
(setq p4-yizu3 (cons (nth (+ p4-num 2) asd-cir1) p4-yizu3))
(setq p4-yizu0 nil)
(setq p4-yizu0 (cons (nth (+ p4-num 3) asd-cir1) p4-yizu0))
(setq p4-yizu0 (cons (nth (+ p4-num 2) asd-cir1) p4-yizu0))
(setq p4-yizu0 (cons (nth (+ p4-num 1) asd-cir1) p4-yizu0))
(if (= (nth p5-num asd-cir1) 2)
(progn
(if (and (/= (member (nth (+ p5-num 1) asd-cir1) p4-yizu0) nil) (/= (member (nth (+ p5-num 2) asd-cir1) p4-yizu0) nil))
()
(setq test1 1)))
(progn
(setq tem1 (nth (+ p5-num 1) asd-cir1))
(setq tem2 (nth (+ p5-num 2) asd-cir1))
(setq tem3 (nth (+ p5-num 3) asd-cir1))
(if(or
  (or (and (member tem1 p4-yizu0) (member tem2 p4-yizu0) ) (and (member tem1 p4-yizu0) (member tem3 p4-yizu0)))
(and (member tem2 p4-yizu0) (member tem3 p4-yizu0)))
()
(setq test1 1))))))
(if (= (nth (+ p4-num 1) asd-cir1) (nth (+ p4-num 2) asd-cir1))
  (setq test1 0))
  (if (equal p4 p5)
(setq test1 1))
(while (and (< j entlen) (= test1 0))
(setq ent2 (ssname entall j))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
(setq px (cdr (assoc 10 (entget ent2))))
(setq py (cdr (assoc 11 (entget ent2))))
(if (/= (inters p4 p5 px py) nil)
(setq test1 1))))
  (setq j (1+ j)))
(if (= test1 0)
  (progn
(setq asd-p4-yizu (cons p5 (cons rp5 (cons p5-num asd-p4-yizu))))
(setq asd-p4 (cons asd-p4-yizu asd-p4))
(setq f (open "test3.txt" "a"))
(write-line (strcat "(" (rtos (car p5)) " " (rtos (cadr p5)) " " (rtos (caddr p5)) ")") f)
(write-line (rtos p5-num) f)
(close f))))
(setq asd-p4-num (length asd-p4))
(setq i 0)
(repeat (- asd-p4-num 1)
  (setq p7 (nth 0 (nth i asd-p4)))
  (setq rp7 (nth 1 (nth i asd-p4)))
  (setq j (+ i 1))
  (setq j-tem j)
  (repeat (- asd-p4-num j-tem)
  (setq p8 (nth 0 (nth j asd-p4)))
  (setq p7 (nth 0 (nth i asd-p4)))
  (if (> (distance p4 p7) (distance p4 p8))
  (progn
  (setq v1 (nth i asd-p4)
  v2 (nth j asd-p4)
  asd-p4 (subst uu v1 asd-p4)
  asd-p4 (subst v1 v2 asd-p4)
  asd-p4 (subst v2 uu asd-p4))))
  (setq j (1+ j)))
  (setq i (1+ i)))
  (setq sabi 0)
  (repeat (length asd-p4)
(setq f (open "test4.txt" "a"))
(write-line (strcat "(" (rtos (car (nth 0 (nth sabi asd-p4)))) " " (rtos (cadr (nth 0 (nth sabi asd-p4)))) " " (rtos (caddr (nth 0 (nth sabi asd-p4)))) ")") f)
(write-line (rtos (nth 2 (nth sabi asd-p4))) f)
(close f)
(setq sabi (1+ sabi)))
  (setq f (open "test3.txt" "a"))
  (close f)
```

```
  (setq i 0)
  (setq p4-lianjie nil)
  (setq 3-yizu-ji nil)
  (while (< i asd-p4-num)
(setq p9 (nth 0 (nth i asd-p4)))
(setq rp9 (nth 1 (nth i asd-p4)))
(setq p9-num (nth 2 (nth i asd-p4)))
##########################
(if (= (nth p4-num asd-cir1) 2)
(progn
(if (= i 0)
(progn
(setq test2 0)
(setq k 0)
(while (and (< k (/ (length asd-cir) 2)) (= test2
0) )
  (setq yuan (nth (* 2 k) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 k)) asd-cir))
  (setq ang3 (abs (- (angle p4 yuan) (angle p4
p9))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq chuidian (polar yuan (+ (angle p4 p9) (/
3.1415926 2)) 100))
  (setq jiaodian (inters p4 p9 chuidian yuan nil))
  (if (and(or (< (* (- (car jiaodian)(car p4)) (-
(car jiaodian) (car p9)) ) 0) (< (* (- (cadr
jiaodian)(cadr p4)) (- (cadr jiaodian) (cadr
p9)) ) 0))
  (and
  (and (> (distance yuan p4) yuan-r) (>
(distance yuan p9) yuan-r))
  (< (* (sin ang3) (distance p4 yuan)) yuan-r)))
(setq test2 1))
(setq k (1+ k)))
  (if (= test2 0)
(progn
(entmake (list
'(0 . "LINE")
'(100 . "AcDbEntity")
'(100 . "AcDbLine")
(cons 10 p4)
(cons 11 p9)))
(if (= (nth (+ p4-num 1) asd-cir1) (nth (+
p4-num 2) asd-cir1))
  (setq i asd-p4-num))
(setq test-output 0)
(setq h 0)
(repeat (length quanbu-line)
  (setq p4-t (nth 0 (nth h quanbu-line)))
  (setq p9-t (nth 2 (nth h quanbu-line)))
  (if (or (and (< (distance p4 p4-t) 1) (<
(distance p9 p9-t) 1)) (and (< (distance p4 p9-t)
1) (< (distance p9 p4-t) 1)))
(setq test-output 1))
  (setq h (1+ h)))
(if (= test-output 0)
(progn
(setq yizu-line nil)
(setq yizu-line (cons p4 (cons rp4 (cons p9
(cons rp9 yizu-line)))))
(setq quanbu-line (cons yizu-line
quanbu-line))))
  (setq p4-lianjie (cons p9 p4-lianjie))
  (setq f (open "test.txt" "a"))
  (write-line (strcat "(" (rtos (car p4)) " " (rtos
(cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (strcat "(" (rtos (car p9)) " " (rtos
(cadr p9)) " " (rtos (caddr p9)) ")") f)
  (write-line (strcat "(" (rtos (nth (+ p4-num 1)
asd-cir1)) " " (rtos (nth (+ p4-num 2)
asd-cir1))")") f)
  (write-line (strcat "(" (rtos (nth (+ p9-num 1)
asd-cir1)) " " (rtos (nth (+ p9-num 2)
asd-cir1))")") f)
(write-line (rtos p9-num) f)
  (close f))))
  (progn
  (setq p4-lianjie-tem p4-lianjie)
  (setq test2 0)
  (while (setq p3 (car p4-lianjie-tem))
  (setq p4-lianjie-tem (cdr p4-lianjie-tem))
  (if (< (distance p3 p9) (distance p4 p9))
  (setq test2 1)))
(setq k 0)
(while (and (< k (/ (length asd-cir) 2)) (= test2
0) )
  (setq yuan (nth (* 2 k) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 k)) asd-cir))
  (setq ang3 (abs (- (angle p4 yuan) (angle p4
p9))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq chuidian (polar yuan (+ (angle p4 p9) (/
3.1415926 2)) 100))
  (setq jiaodian (inters p4 p9 chuidian yuan nil))
  (if (and(or (< (* (- (car jiaodian)(car p4)) (-
(car jiaodian) (car p9)) ) 0) (< (* (- (cadr
jiaodian)(cadr p4)) (- (cadr jiaodian) (cadr
p9)) ) 0))
  (and
  (and (> (distance yuan p4) yuan-r) (>
(distance yuan p9) yuan-r))
  (< (* (sin ang3) (distance p4 yuan)) yuan-r)))
(setq test2 1))
(setq k (1+ k)))
      (if (= test2 0)
  (progn
(entmake (list
'(0 . "LINE")
'(100 . "AcDbEntity")
'(100 . "AcDbLine")
(cons 10 p4)
(cons 11 p9)))
```

```
(if (= (nth (+ p4-num 1) asd-cir1) (nth (+ p4-num 2) asd-cir1))
  (setq i asd-p4-num))
(setq test-output 0)
(setq h 0)
(repeat (length quanbu-line)
  (setq p4-t (nth 0 (nth h quanbu-line)))
  (setq p9-t (nth 2 (nth h quanbu-line)))
  (if (or (and (< (distance p4 p4-t) 1) (< (distance p9 p9-t) 1)) (and (< (distance p4 p9-t) 1) (< (distance p9 p4-t) 1)))
(setq test-output 1))
  (setq h (1+ h)))
(if (= test-output 0)
(progn
(setq yizu-line nil)
(setq yizu-line (cons p4 (cons rp4 (cons p9 (cons rp9 yizu-line)))))
(setq quanbu-line (cons yizu-line quanbu-line))))
  (setq f (open "test.txt" "a"))
  (write-line (strcat "(" (rtos (car p4)) " " (rtos (cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (strcat "(" (rtos (car p9)) " " (rtos (cadr p9)) " " (rtos (caddr p9)) ")") f)
  (write-line (strcat "(" (rtos (nth (+ p4-num 1) asd-cir1)) " " (rtos (nth (+ p4-num 2) asd-cir1))")") f)
  (write-line (strcat "(" (rtos (nth (+ p9-num 1) asd-cir1)) " " (rtos (nth (+ p9-num 2) asd-cir1))")") f)
(write-line (rtos p9-num) f)
  (close f)
  (setq p4-lianjie (cons p9 p4-lianjie))
  (if (> (length p4-lianjie) 1)
  (setq i asd-p4-num)))))))
(progn
(setq test2 0)
(setq 3-yizu nil)
(setq j 0)
(repeat (nth p9-num asd-cir1)
(setq j (1+ j))
(setq 3-yizu (cons (nth (+ p9-num j) asd-cir1) 3-yizu)))
(setq j 0)
(repeat (- (nth p9-num asd-cir1) 1)
(setq k (+ j 1))
(setq j-tem (+ 1 j))
(repeat (- (nth p9-num asd-cir1) j-tem)
  (if (< (nth j 3-yizu) (nth k 3-yizu))
(progn
  (setq tem (nth j 3-yizu))
  (setq temr (nth k 3-yizu))
  (setq 3-yizu
  (subst cao5 (nthk 3-yizu) 3-yizu))
  (setq 3-yizu
  (subst cao6 (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtemr (nthj 3-yizu) 3-yizu))
  (setq 3-yizu
  (substtem (nthk 3-yizu) 3-yizu))))
  (setq k (1+ k)))
(setq j (1+ j)))
(if (member 3-yizu 3-yizu-ji)
  (setq test2 1))
(if (= (nth p9-num asd-cir1) 3)
(progn
(if(and (and (/= (nth 0 3-yizu) (nth (+ p4-num 1) asd-cir1))
(/= (nth 0 3-yizu) (nth (+ p4-num 2) asd-cir1)))
(/= (nth 0 3-yizu) (nth (+ p4-num 3) asd-cir1)) )
  (setq testzu (cons (nth 1 3-yizu) (cons (nth 2 3-yizu) nil))))
(if(and (and (/= (nth 1 3-yizu) (nth (+ p4-num 1) asd-cir1))
(/= (nth 1 3-yizu) (nth (+ p4-num 2) asd-cir1)))
(/= (nth 1 3-yizu) (nth (+ p4-num 3) asd-cir1)) )
  (setq testzu (cons (nth 0 3-yizu) (cons (nth 2 3-yizu) nil))))
(if(and (and (/= (nth 2 3-yizu) (nth (+ p4-num 1) asd-cir1))
(/= (nth 2 3-yizu) (nth (+ p4-num 2) asd-cir1)))
(/= (nth 2 3-yizu) (nth (+ p4-num 3) asd-cir1)) )
  (setq testzu (cons (nth 0 3-yizu) (cons (nth 1 3-yizu) nil))))
  (setq f (open "test2.txt" "a"))
(write-line (rtos (nth p9-num asd-cir1)) f)
  (close f)
  (if (/= (member testzu 3-yizu-ji) nil)
  (setq test2 1))))
(setq k 0)
(while (and (< k (/ (length asd-cir) 2)) (= test2 0) )
  (setq yuan (nth (* 2 k) asd-cir))
  (setq yuan-r (nth (+ 1 (* 2 k)) asd-cir))
  (setq ang3 (abs (- (angle p4 yuan) (angle p4 p9))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
  (setq chuidian (polar yuan (+ (angle p4 p9) (/ 3.1415926 2)) 100))
  (setq jiaodian (inters p4 p9 chuidian yuan nil))
  (if (and(or (< (* (- (car jiaodian)(car p4)) (- (car jiaodian) (car p9)) ) 0) (< (* (- (cadr jiaodian)(cadr p4)) (- (cadr jiaodian) (cadr p9)) ) 0))
  (and
  (and (> (distance yuan p4) yuan-r) (> (distance yuan p9) yuan-r))
  (< (* (sin ang3) (distance p4 yuan)) yuan-r)))
(setq test2 1))
(setq k (1+ k)))
(if (= test2 0)
  (progn
```

```
(entmake (list
'(0 . "LINE")
'(100 . "AcDbEntity")
'(100 . "AcDbLine")
(cons 10 p4)
(cons 11 p9)))
  (setq en (entlast))
  (setq ed (entget en))
  (setq en (entlast))
  (setq ed (entget en))
  (setq ed
(subst (cons 11 (list (car p9) (cadr p9) (caddr p9))) (assoc 11 ed) ed))
  (entmod ed)
  (setq ed
(subst (cons 10 (list (car p4) (cadr p4) (caddr p4))) (assoc 10 ed) ed))
  (entmod ed)
(setq test-output 0)
(setq h 0)
(repeat (length quanbu-line)
  (setq p4-t (nth 0 (nth h quanbu-line)))
  (setq p9-t (nth 2 (nth h quanbu-line)))
  (if (or (and (< (distance p4 p4-t) 1) (< (distance p9 p9-t) 1)) (and (< (distance p4 p9-t) 1) (< (distance p9 p4-t) 1)))
(setq test-output 1))
  (setq h (1+ h)))
(if (= test-output 0)
(progn
(setq yizu-line nil)
(setq yizu-line (cons p4 (cons rp4 (cons p9 (cons rp9 yizu-line)))))
(setq quanbu-line (cons yizu-line quanbu-line))))
  (setq f (open "test1.txt" "a"))
  (write-line (strcat "(" (rtos (car p4)) " " (rtos (cadr p4)) " " (rtos (caddr p4)) ")") f)
  (write-line (strcat "(" (rtos (car p9)) " " (rtos (cadr p9)) " " (rtos (caddr p9)) ")") f)
  (write-line (strcat "(" (rtos (nth (+ p4-num 1) asd-cir1)) " " (rtos (nth (+ p4-num 2) asd-cir1)) " " (rtos (nth (+ p4-num 3) asd-cir1)) ")") f)
  (setq mabi 1)
  (repeat (nth p9-num asd-cir1)
(write-line (rtos (nth (+ p9-num mabi) asd-cir1)) f)
(setq mabi (1+ mabi)))
  (write-line (rtos (length 3-yizu-ji)) f)
  (write-line (rtos p9-num) f)
      ########################output)
  (close f)
  (setq p4-lianjie (cons p9 p4-lianjie))
  (setq 3-yizu-ji (cons 3-yizu 3-yizu-ji))))))
#########################
(setq i (1+ i)))
  (setq asd-lianjie (cons p4-lianjie asd-lianjie)))
#########################shanxian
(setq test 0)
(while (= test 0)
  (setq ent2 (entsel "please choose a line you want to delete"))
(setq ent3 (cdr (assoc 0 (entget (car ent2)))))
  (if (= ent3 "LINE")
(progn
(setq px1 (cdr (assoc 10 (entget (car ent2)))))
(setq py1 (cdr (assoc 11 (entget (car ent2)))))
  (setq i 0)
  (setq test1 0)
  (while (and (= test1 0) (< i (length quanbu-line)))
(setq 1-line (nth i quanbu-line))
(if (or (and (equal (nth 0 1-line) px1) (equal (nth 2 1-line) py1))
(and (equal (nth 0 1-line) py1) (equal (nth 2 1-line) px1)))
  (progn
(setq quanbu-line (vl-remove (nth i quanbu-line) quanbu-line))
(setq test1 1)))
(setq i (1+ i)))))
  (if (= (getstring "If you want to delete another line") "y" )
(setq test 0)
(setq test 1)))
#########################shanxian
#######################output
  (setq i 0)
  (repeat (length quanbu-line)
  (setq p4 (nth 0 (nth i quanbu-line)))
  (setq rp4 (nth 1 (nth i quanbu-line)))
  (setq p9 (nth 2 (nth i quanbu-line)))
  (setq rp9 (nth 3 (nth i quanbu-line)))
  (setq f (open (strcat dire "line.csv") "a"))
  (write-line (strcat (rtos 0) "," (rtos rp4)"" ) f)
  (write-line (strcat (rtos (distance p4 p9)) "," (rtos rp9)"" ) f)
  (write-line "" f)
  (close f)
  (setq i (1+ i)))
```

7. Auto CAD programming 3 – Detection of nearest route between intersections and nearest exit

```
(Defun C:routee()
(setq dire (getstring "Please input the directory you want to read the circle file") )
(setq asd-cir nil)
(setq asd-cir1 nil)
(setq asd-cir2 nil)
(setq asd-cir3 nil)
(setq 3-circle nil)
  (setq f (open "test.txt" "w"))
  (close f)
  (setq f (open "test1.txt" "w"))
  (close f)
  (setq f (open "test2.txt" "w"))
  (close f)
  (setq f (open "test3.txt" "w"))
  (close f)
  (setq f (open "test4.txt" "w"))
  (close f)
  (setq f (open (strcat dire "line.csv") "w"))
  (close f)
  (setq f (open (strcat dire "routee.csv") "w"))
  (close f)
(setq asd1 nil)
(setq asd-lianjie nil)
(setq entall (ssget "X"))
(setq entlen (sslength entall))。。
(setq cao1 (list 232432 233 4354) )
(setq cao2 34534)
(setq cao3 (list 2312 35434 23132))
(setq cao4 90523)
(setq cao5 78723)
(setq cao6 66623)
(setq f (open (strcat dire "circle.txt") "r"))
(while (setq p4 (read-line f))
(setq p4 (read p4))
(setq rp4 (read-line f))
(setq rp4 (read rp4))
(setq asd-cir (cons p4 asd-cir)))
(close f)
(setq f (open (strcat dire "circle1.txt") "r"))
(while (setq num (read-line f))
(setq num (read num))
(setq asd-cir3 (cons num asd-cir3)))
  (close f)
  (setq i 0)
  (repeat (length asd-cir3)
  (setq asd-cir1 (cons (nth i asd-cir3) asd-cir1))
  (setq i (1+ i)))
(setq f (open (strcat dire "circle2.txt") "r"))
(while (setq num (read-line f))
(setq num (read num))
(setq asd-cir2 (cons num asd-cir2)))
(close f)
(setq exits nil)
(while (/= (getstring "Is there still exits?") "y")
(setq one-exit nil)
(setq st-p (getpoint "Please set the starting point you want"))
(setq s (cons st-p nil))
(setq yizu (cons 0 (cons 0 (cons -1 nil))))
(setq T (cons yizu nil))
(setq test1 1)
(setq indi 1)
(while (and (< (length s) (length asd-cir)) (= test1 1) )
(setq test1 0)
(setq i 0)
(setq jihe nil)
(repeat (length s)
(setq dian (nth i s))
(setq dian-ju (nth i T))
(setq j 0)
  (repeat (length quanbu-line)
  (if (or (equal dian (nth 0 (nth j quanbu-line)))
(equal dian (nth 2 (nth j quanbu-line))))
  (progn
  (if (equal dian (nth 0 (nth j quanbu-line)))
(setq test-dian (nth 2 (nth j quanbu-line)))
(setq test-dian (nth 0 (nth j quanbu-line))))
  (setq test2 0)
  (setq k 0)
  (while (and (< k (length s)) (= test2 0) )
(if (equal (nth k s) test-dian)
(setq test2 1))
(setq k (1+ k)))
  (if (= test2 0)
(progn
(setq test1 1)
(setq yizu-tem (cons dian (cons test-dian (cons dian-ju nil))))
(setq jihe (cons yizu-tem jihe))))))
(setq j (1+ j)))
  (setq i (1+ i)))
(if (= test1 1)
(progn
  (setq i 0)
  (setq min 9999)
  (repeat (length jihe)
(setq dian1 (nth 0 (nth i jihe)))
(setq dian2 (nth 1 (nth i jihe)))
(setq pre-ju (nth 0 (nth 2 (nth i jihe))))
(if (< (+ (distance dian1 dian2) pre-ju) min)
(progn
(setq min (+ (distance dian1 dian2) pre-ju))
(setq pl-p (nth i jihe))))
(setq i (1+ i)))
```

```
  (setq s (cons (nth 1 pl-p) s))
  (setq yizu (cons min (cons indi (cons (nth 1
(nth 2 pl-p)) nil))))
  (setq T (cons yizu T))
  (setq indi (1+ indi)))))
(setq one-exit (cons st-p (cons s (cons T
one-exit))))
(setq exits (cons one-exit exits)))
########################################
########################################
  (setq 3-dian nil)
  (setq 3-dian-zu nil)
  (setq i 0)
  (setq p-num 0)
  (setq f (open (strcat dire "routee.csv") "w"))
  (repeat (length asd-cir)
(setq p4 (nthi asd-cir))
(setq p4-num (nth i asd-cir2))
(if (= (nth p4-num asd-cir1) 3)
(progn
(setq p-num (1+ p-num))
(setq j 0)
(setq min 999999)
(setq posi 999999)
(setq posi-2 99999)
(repeat (length exits)
(setq s (nth 1 (nth j exits)))
(setq t (nth 2 (nth j exits)))
(setq test10 0)
(setq fi-num 0)
(setq k 0)
(repeat (length s)
(if (equal (nth k s) p4)
  (progn
  (setq fi-num k)
  (setq test10 1)))
  (setq k (1+ k)))
(if (= test10 1)
  (progn
(if (< (nth 0 (nth fi-num t)) min)
  (progn
(setq min (nth 0 (nth fi-num t)))
(setq posi j)
(setq posi-2 fi-num)))))
(setq j (1+ j)))
  (setq 3-dian-zu (cons p4 (cons min (cons posi
(cons posi-2 nil)))))
  (setq 3-dian (cons 3-dian-zu 3-dian))
  (if (= min 999999)
(progn
(write-line (strcat (rtos p-num) "," "-" "" ) f))
(progn
(write-line (strcat (rtos p-num) "," (rtos min)"" )
f)
  (entmake (list '(0 . "TEXT") (cons 10 p4)
(cons 40 90)
  (cons 1 (strcat "No." (rtos p-num) "Min-dis:"
(rtos min)))
  '(40 . 20)))))))
  (setq i (1+ i)))
(close f)
########################################
########################################
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 10)
'(70 . 0)
(cons 2 "routee")))
(setvar "clayer" "routee")
(setq where 0)
(repeat (length 3-dian)
(if (/=(nth 1 (nth where 3-dian))999999 )
(progn
(setq fi-p (nth 0 (nth where 3-dian)))
(setq s (nth 1 (nth (nth 2 (nth where 3-dian))
exits)))
(setq t (nth 2 (nth (nth 2 (nth where 3-dian))
exits)))
(setq st-p (nth 0 (nth (nth 2 (nth where 3-dian))
exits)))
(setq st-fi (cons fi-p nil))
(setq fi-num 0)
(setq i 0)
(repeat (length s)
(if (equal (nth i s) fi-p)
  (setq fi-num i))
(setq i (1+ i)))
(while (and (/= (nth 2 (nth fi-num T)) 0) (/=
(nth 2 (nth fi-num T)) -1))
(setq st-fi (cons (nth (-(- (length s) 1) (nth 2
(nth fi-num T)) ) s) st-fi))
(setq fi-num (- (- (length s) 1) (nth 2 (nth
fi-num T)))))
  (setq st-fi (cons st-p st-fi))
  (setq i 0)
  (if (= (equal st-fi st-p) nil)
  (progn
  (repeat (- (length st-fi) 1)
  (setq p4 (nth i st-fi))
  (setq p9 (nth (+ 1 i) st-fi))
  (if (= (equal p4 p9) nil)
(entmake (list
'(0 . "LINE")
'(100 . "AcDbEntity")
'(100 . "AcDbLine")
(cons 10 p4)
(cons 11 p9))))
  (setq i (1+ i)))))))
  (setq where (1+ where))))
```

8. Auto CAD programming 4 – visualization analysis

```
(Defun C:visual()
(setq dire (getstring "Please input the directory
you want to read the circle file") )
(setq asd-cir nil)
(setq asd-cir1 nil)
(setq asd-cir2 nil)
(setq asd-cir3 nil)
(setq 3-circle nil)
  (setq f (open "test.txt" "w"))
  (close f)
  (setq f (open "test1.txt" "w"))
  (close f)
  (setq f (open "test2.txt" "w"))
  (close f)
  (setq f (open "test3.txt" "w"))
  (close f)
  (setq f (open "test4.txt" "w"))
  (close f)
  (setq f (open (strcat dire "line.csv") "w"))
  (close f)
  (setq f (open (strcat dire "routee.csv") "w"))
  (close f)
(setq asd1 nil)
(setq asd-lianjie nil)
  (setq entall (ssget "x" '((8 . "building"))))
(setq entlen (sslength entall))
  (setq entall1 (ssget "x" '((8 . "line") (0 .
"LINE") )))
(setq entlen1 (sslength entall1))
(setq cao1 (list 232432 233 4354) )
(setq cao2 34534)
(setq cao3 (list 2312 35434 23132))
(setq cao4 90523)
(setq cao5 78723)
(setq cao6 66623)
(setq f (open (strcat dire "circle.txt") "r"))
(while (setq p4 (read-line f))
(setq p4 (read p4))
(setq rp4 (read-line f))
(setq rp4 (read rp4))
(setq asd-cir (cons p4 asd-cir)))
(close f)
(setq f (open (strcat dire "circle1.txt") "r"))
(while (setq num (read-line f))
(setq num (read num))
(setq asd-cir3 (cons num asd-cir3)))
  (close f)
  (setq i 0)
  (repeat (length asd-cir3)
  (setq asd-cir1 (cons (nth i asd-cir3) asd-cir1))
  (setq i (1+ i)))
(setq f (open (strcat dire "circle2.txt") "r"))
(while (setq num (read-line f))
(setq num (read num))
(setq asd-cir2 (cons num asd-cir2)))
(close f)
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 180)
'(70 . 0)
(cons 2 "visual1")))
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 160)
'(70 . 0)
(cons 2 "visual2")))
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 140)
'(70 . 0)
(cons 2 "visual3")))
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 120)
'(70 . 0)
(cons 2 "visual4")))
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 100)
'(70 . 0)
(cons 2 "visual5")))
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 80)
'(70 . 0)
(cons 2 "visual6")))
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 60)
'(70 . 0)
```

```
(cons 2 "visual7")))
(entmake (list
'(0 . "LAYER")
'(100 . "AcDbSymbolTableRecord")
'(100 . "AcDbLayerTableRecord")
'(6 . "CONTINUOUS")
'(62 . 40)
'(70 . 0)
(cons 2 "visual8")))
#####################################
#####################################
(setq indi(getint "please input how many divides in 100m"))
(setq j 0)
(repeat (length quanbu-line)
  (setq p1 (nth 0 (nth j quanbu-line)))
  (setq p2 (nth 2 (nth j quanbu-line)))
  (setq min1 (nth 1 (assoc p1 3-dian)))
  (setq min2 (nth 1 (assoc p2 3-dian)))
  (setq k 0)
  (setq divi (* (/ (distance p1 p2) 100) indi))
  (setq num (fix divi))
  (repeat num
  (setq dis1 (* (/ (distance p1 p2) divi) k))
  (setq dis2 (- (distance p1 p2) dis1))
  (setq ppp(polar p1 (angle p1 p2) (* (/ (distance p1 p2) divi) k)))
  (if (< (+ min1 dis1) (+ min2 dis2) )
  (setq minmin (+ min1 dis1))
  (setq minmin (+ min2 dis2)))
#####################################
#################
(setq pppp (polar ppp (+ (angle p1 p2)(/ 3.1415926 2)) 100))
  (setq jj 0)
  (setq short 999999)
  (repeat entlen
(setq ent2 (ssname entall jj))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
(setq px1 (cdr (assoc 10 (entget ent2))))
(setq py1 (cdr (assoc 11 (entget ent2))))
(setq jiaodian (inters ppp pppp px1 py1 nil))
(if (and (or (< (* (- (car jiaodian)(car px1)) (- (car jiaodian) (car py1)) ) 0) (< (* (- (cadr jiaodian)(cadr px1)) (- (cadr jiaodian) (cadr py1)) ) 0))
  (< (distance jiaodian ppp) short))
  (setq short (distance jiaodian ppp)))))
  (setq jj (1+ jj)))
(setq jj 0)
(setq divi1 (* (/ short 100) indi))
(setq num1 (fix divi1))
(repeat num1
  (setq new-cir (polar ppp (angle ppp pppp) (* (/ short divi1) (+ 1 jj))))
  (setq new-cir1 (polar ppp (angle pppp ppp) (* (/ short divi1) (+ 1 jj))))
  (setq dis3(* (/ short divi1) (+ 1 jj)))

#####################################
########
  (setq test1 0)
  (setq kk 0)
(while (and (< kk entlen1) (= test1 0) )
(setq ent2 (ssname entall1 kk))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (if (= (or (and (equal px1 p1) (equal py1 p2)) (and (equal px1 p2) (equal py1 p1))) nil)
  (progn
  (setq ang3 (abs (- (angle px1 new-cir) (angle px1 py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
(setq ang4 (abs (- (angle py1 new-cir) (angle py1 px1))))
(if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
(if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 new-cir) (- dis3 0.1))
(setq test1 1)))
  (progn
(if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 new-cir) (- dis3 0.1))
(setq test1 1)))
(progn
(if (< (* (distance new-cir px1) (sin ang3)) (- dis3 0.1))
(setq test1 1)))))))))
  (setq kk (1+ kk)))
(if (= test1 0)
(progn
#####################################
#########
  (setq minmin1 (+ minmindis3))
#################################
(if (< minmin1 42)
  (progn
(setvar "clayer" "visual1")
  (setq ed (entmake (list
  '(0 . "POINT")
(cons 62 180)
(cons 10 new-cir)))))
  (progn
  (if (< minmin1 84)
(progn
(setvar "clayer" "visual2")
```

```
(setq ed (entmake (list
'(0 . "POINT")
  (cons 62 160)
(cons 10 new-cir)))))
  (progn
(if (< minmin1 126)
(progn
  (setvar "clayer" "visual3")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 62 140)
(cons 10 new-cir)))))
(progn
(if (< minmin1 168)
  (progn
(setvar "clayer" "visual4")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 62 120)
(cons 10 new-cir)))))
  (progn
  (if (< minmin1 210)
  (progn
(setvar "clayer" "visual5")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 62 100)
(cons 10 new-cir)))))
  (progn
  (if (< minmin1 252)
(progn
(setvar "clayer" "visual6")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 6280)
(cons 10 new-cir)))))
(progn
  (if (< minmin1 294)
(progn
  (setvar "clayer" "visual7")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 6260)
(cons 10 new-cir)))))
  (progn
  (setvar "clayer" "visual8")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 6240)
(cons 10 new-cir))))))))))))))))
###################################))
#####################################
###################### new-cir1
  (setq test1 0)
  (setq kk 0)
(while (and (< kk entlen1) (= test1 0) )
(setq ent2 (ssname entall1 kk))
(setq ent3 (cdr (assoc 0 (entget ent2))))
(if(= ent3 "LINE")
(progn
  (setq px1 (cdr (assoc 10 (entget ent2 ))))
  (setq py1 (cdr (assoc 11 (entget ent2 ))))
  (if (= (or (and (equal px1 p1) (equal py1 p2))
(and (equal px1 p2) (equal py1 p1))) nil)
  (progn
  (setq ang3 (abs (- (angle px1 new-cir1) (angle
px1 py1))))
  (if (> ang3 3.1415926)
  (setq ang3 (- 6.2831852 ang3 )))
(setq ang4 (abs (- (angle py1 new-cir1) (angle
py1 px1))))
(if (> ang4 3.1415926)
  (setq ang4 (- 6.2831852 ang4 )))
(if (> ang3 (/ 3.1415926 2))
  (progn
(if (< (distance px1 new-cir1) (- dis3 0.1))
(setq test1 1)))
  (progn
(if (> ang4 (/ 3.1415926 2))
(progn
(if (< (distance py1 new-cir1) (- dis3 0.1))
(setq test1 1)))
(progn
(if (< (* (distance new-cir1 px1) (sin ang3)) (-
dis3 0.1))
(setq test1 1)))))))))
  (setq kk (1+ kk)))
(if (= test1 0)
(progn
#####################################
#########
  (setq minmin2 (+ minmindis3))
#################################
(if (< minmin2 42)
  (progn
(setvar "clayer" "visual1")
  (setq ed (entmake (list
  '(0 . "POINT")
(cons 62 180)
(cons 10 new-cir1)))))
  (progn
  (if (< minmin2 84)
(progn
(setvar "clayer" "visual2")
(setq ed (entmake (list
'(0 . "POINT")
  (cons 62 160)
(cons 10 new-cir1)))))
  (progn
(if (< minmin2 126)
(progn
  (setvar "clayer" "visual3")
(setq ed (entmake (list
  '(0 . "POINT")
```

```
  (cons 62 140)
(cons 10 new-cir1)))))
(progn
(if (< minmin2 168)
  (progn
(setvar "clayer" "visual4")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 62 120)
(cons 10 new-cir1)))))
  (progn
  (if (< minmin2 210)
  (progn
(setvar "clayer" "visual5")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 62 100)
(cons 10 new-cir1)))))
  (progn
  (if (< minmin2 252)
(progn
(setvar "clayer" "visual6")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 6280)
(cons 10 new-cir1)))))
(progn
  (if (< minmin2 294)
(progn
  (setvar "clayer" "visual7")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 6260)
(cons 10 new-cir1)))))
  (progn
  (setvar "clayer" "visual8")
(setq ed (entmake (list
  '(0 . "POINT")
  (cons 6240)
(cons 10 new-cir1))))))))))))))))))
####################################))

#####################################
###################### newc-cir1
  (setq jj (1+ jj)))
#####################################
################
(setq k (1+ k))(setq j (1+ j)))
#####################################
################
#####################################
##############)
```

9. Excel programming of evacuation time calculation 1 – in signal route

```
Attribute VB_Name = "ﾄｺﾘ・"
Sub dilidi()

Dim i As Integer
Dim a(500) As Double
Dim b As Integer
Dim aver As Double
Dim test As Integer
Dim max As Integer
Dim j As Integer
Dim max1 As Integer
Dim averper As Double
Dim speed As Double
Dim time(500) As Double
Dim temp As Double
Dim ii As Integer

test = 0
aver = 2
averper = 24
speed = 1.4
b = 0
max = 200
max1 = 200
ii = 0

For i = 1 To max1
time(i) = Cells(i, 3).Value
If (time(i) < 0) Then
  ii = i - 1
GoTo lable1
End If
Next

lable1:
For i = 1 To max
temp = 0
  For j = 1 To ii
  If (i > time(j) And (i < time(j) + averper))
Then
  temp = temp + speed
  End If
  Next
Cells(i, 1) = temp
Next

For i = 1 To max
a(i) = Cells(i, 1).Value
Next

For i = 1 To max
If a(i) > aver Then
b = b + a(i) - aver
a(i) = aver

Else
If b > 0 Then
If aver - a(i) < b Then
  b = b - (aver - a(i))
  a(i) = aver
  Else
  a(i) = a(i) + b
  b = 0
End If
End If
End If

Next


Do
i = i + 1
If (b > Average) Then
a(i) = Average
b = b - Average
Else
a(i) = b
b = 0
End If

Loop While (b > 0)
j = i


For i = 1 To j
Cells(i, 2).Value = a(i)
Next


End Sub
```

10. Excel programming of evacuation time calculation 2 – flow of routes

```
Attribute VB_Name = "ﾄｺﾘ・"
Sub initial()

Dim i As Integer
Dim j As Integer
Dim max As Integer

max = 1000

  For i = 1 To max
  For j = 1 To max
  Cells(i, j).Value = -1
  Next
  Next

End Sub

Attribute VB_Name = "ﾄｺﾘ・"
Sub dilidi()

Dim i As Integer
Dim a(2000) As Double
Dim b As Integer
Dim aver As Double
Dim test As Integer
Dim max As Integer
Dim j As Integer
Dim k As Integer
Dim max1 As Integer
Dim averper(200) As Double
Dim speed(200, 1000) As Double
Dim time(200) As Double
Dim temp As Double
Dim ii As Integer
Dim personspeed As Double

test = 0
aver = 2
b = 0
max = 1000
max1 = 1000
ii = 0
personspeed = 2
For i = 1 To max
time(i) = Cells(1, i + 4).Value
test = 0
For j = 2 To max
  If (Cells(j, i + 4) < 0 And test = 0) Then
averper(i) = j - 2
test = 1
Else
If (test = 0) Then
speed(i, j - 1) = Cells(j, i + 4).Value
End If
  End If

Next

If (time(i) < 0) Then
  ii = i - 1
GoTo lable1
End If
Next

lable1:
For i = 1 To max
temp = 0
  For j = 1 To ii
  If (i > time(j) / personspeed And (i < time(j) /
personspeed + averper(j))) Then
  temp = temp + speed(j, i - time(j) /
personspeed)
  End If
  Next
Cells(i, 1) = temp
Next

For i = 1 To max
a(i) = Cells(i, 1).Value
Next

For i = 1 To max
If a(i) > aver Then
b = b + a(i) - aver
a(i) = aver
Else
If b > 0 Then
If aver - a(i) < b Then
  b = b - (aver - a(i))
  a(i) = aver
  Else
  a(i) = a(i) + b
  b = 0
End If
End If
End If
Next

Do
i = i + 1
If (b > Average) Then
a(i) = Average
b = b - Average
Else
a(i) = b
b = 0
```

```
End If

Loop While (b > 0)
j = i
For i = 1 To j
Cells(i, 2).Value = a(i)
Next
End Sub
```

References for appendix

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