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THE CONSTRUCTION AND EVALUATION OF THE EARTHQUAKE EMERGENCY LOGISTICS SYSTEM

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Abstract:-Earthquake, as one of the natural disasters, can severely destroy the earth surface and cause a great loss in people's life and property. In recent years, the earthquake has grown with the expansion with its frequency, scale and influence, accounting for a higher demand on emergency logistics. Based on the real situation of earthquake emergency and combined with the relevant theories of emergency management and modern logistics, this paper from the outset analyzes the present situation of earthquake emergency logistics system in Taizhou, and establishes a new emergency logistics system as well as evaluate it by means of the YAAHP. It ends with related suggestions to improve the efficiency of the earthquake emergency logistics system.

Keywords **-** Emergency Logistics; Earthquake; System

I. INTRODUCTION

The frequent occurrence of the floods, typhoons, earthquakes and other natural disasters have seriously affected the development of social production and life in recent years. What is worse, it has greatly threatened the survival of human beings, as is shown in Table 1. The related statistics are all from the Seismic Station in Jiangsu Province.

Table 1 Earthquake records in Jiangsu Province

Time	Position	Magnitude
2014.3.23	Sheyang, Yancheng, Jiangsu Province	M2.0
2014.3.8	Dafeng ,Yancheng ,Jiangsu Province	M2.0
2013.12.30	the junction between Xinghua ,Taizhou and Dongtai, Yancheng Jiangsu Province	M2.4
2013.3.3	the junction between Guanyun and Guannan, Lianyungang Jiangsu Province	M2.5
2012.7.20	the junction between Baoying and Gaoyou , Yangzhou ,Jiangsu Province	M4.9
2012.5.22	Liyang ,Changzhou, Jiangsu Province	M2.5
2012.4.8	Jinhu ,Huaian,Jiangsu Province	M3.6
2011.10.8	Rugao, Nantong, Jiangsu Province	M3.0
2011.1.21	Dongtai , Yancheng, Jiangsu Province	M2.9
2010.11.26	Xinghua , Taizhou, Jiangsu Province	M3.0
2010.4.9	Xinghua , Taizhou, Jiangsu Province	M2.8

According to the statistics released by the station, more than 60 earthquakes have taken place since 2004, all of which caused great loss to people's lives and property. Although the earthquake directly occurring in the urban area had not yet been recorded, there were total three earthquakes happened in and around the city, and two of which happened in surrounding areas. Therefore, it is urgent to take measures of earthquake emergency management to cope with unpredictable disasters[1].

In recent years, Taizhou has entered into a crucial period of drastic and drammatic development in economy and society. Besides it has witnessed a good momentum in economy so that the government began to realize that it is necessary to strengthen the emergency management and establish an effective emergency response mechanism to tackle a great variety of emergency events. The government needs to take quick and effective measures timely and immediately the moment the earthquake happens. The qualified emergent materials should be sent to the destination in a most reasonable way immediately so as to reduce the losses to the minimum. [2,3]. Therefore, it is a must to confront how to take advantage of advanced science and technology, optimize the resource utilization of government and society, as well as enhance the rapid reaction capacity to respond to emergencies.

II. THE STATUS QUO OF TAIZHOU EARTHQUAKE EMERGENCY LOGISTICS SYSTEM

2.1 The unsound earthquake emergency logistics organization system

According to the newly revised "Taizhou Earthquake Emergency Plan " in 2013, the emergency command

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structure diagram of Taizhou disaster organization is shown in Figure 1.

The organizational structure of government is linear which takes advantage of a straight line system and functions of the system.

It is not difficult to find that Taizhou is pressed for management department with specialized, permanent earthquake disaster emergency logistics from Fig. 1. The relevant personnels participating in the emergency logistics itself are dispatched temporally to take responsibility for emergency material procurement, transportation, warehousing, transit, transportation, recycling and other activities, who are scattering in different departments. All lead to the inconvenient communication. In addition, a good interactive mechanism has not yet formed between regions and enterprises, government and department, and the government and enterprises [4]. The disadvantages of the temporary emergency logistics organization and linear function give rise to ineffective and inefficient cooperation and communication between departments, as well as the lack of systematicity and predictability. It is easily inclined to the unsmooth channel for disaster emergency logistics, loose command, and unclear responsibility. This may contribute to the unscientific and untimely distribution of the emergency material.

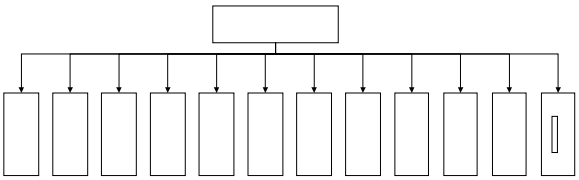

Fig.1 The diagram of Taizhou emergency command structure under the earthquake disaster

2.2 Underdeveloped city traffic infrastructure construction

The urban road traffic system plays an important part in city seismic system. According to the "Taizhou statistical yearbook 2012", the transportation infrastructure in Taizhou is shown in Table 2. it is not difficult to find that the transportation infrastructure, emergency channel construction are incomplete and the urban traffic infrastructure level is low and unbalanced.

Table 2 The table about the Taizhou municipal transportation

Index	unit	The city	downtown area	Xing hua	Jing jiang	Tai xing	Jiang yan
Highway mileage	kilometre	8894	1141	2589	1241	2052	1871
Highway		8868	1135	2569	1241	2052	1871
Expressway		245	25	3	24	74	68
A level highway		733	163	111	135	154	169
Two highway		1357	198	598	160	201	200
Three highway		853	111	94	126	317	206

By the end of 2011, Taizhou's expressway and highway have only accounted for 11%. Some important facilities are disqualified in their relatively low quality, small scale and unreasonable planning. The demerits of urban transportation infrastructure fail to obtain the effective promotion and enhance the efficiency of emergency logistics. Especially, the logistic infrastructure construction will directly affect the efficiency and quality of emergency logistics[5]. In addition, road traffic resources in Taizhou are distributed unevenly. However, by contrast, the traffic conditions are comparatively good and the good transportation mode is relatively complete. Besides, the reasonable city planning, sound structure and solid transportation are good for internal and external links. Compared with the urban area, the traffic conditions in neighboring areas, such as Taixing, and Jingjiang are relatively poor, Xinghua traffic conditions are far worse. Apart from that, some villages have not yet built highways, which leads to the lack communication in and around the city.

2.3 The shortage of emergency logistics talents

Talents of emergency logistics should have a good command of all aspects of knowledge, including carrying out logistics management with various techniques , grasping the knowledge of emergency logistics as well as the management of the whole supply chain and try to make the right decision as soon as possible.

Those logistics management talents are desperately needed in Taizhou at present. So it is hard to meet the needs of the development of the emergency logistics. yet the number of colleges and universities offering courses on logistics management is insufficient, not mentioning the researchers on this field. Practical talents of emergency logistics are extremely short-handed.

2.4 The low level of earthquake emergency logistics information

Information technology plays a pivot role in the development of emergency logistics. Up to now, logistics information platform has not fully developed in Taizhou, let alone a special earthquake emergency logistics information platform. And the regional emergency logistics information sharing condition still needs improving. So, it is detrimental to the development of the emergency logistics coordination in Taizhou and it hinders the development of logistics informationization. The development of emergency logistics is subject to the informatization construction , makeing the contradiction between them even more prominent [6].

The lack of a stable, professional and unified emergency logistics information sharing and publishing platform caused sever information asymmetry. Ascribed to the lack of efficient and accurate information transmission and communication, the emergency logistics command mechanism can not accurately grasp the development of the situation and unable to make the right judgment which may even lead to a situation out of control.

2.5 Undue attention attached to the earthquake emergency supplies

In the process of the emergency work after a devastating earthquake, the government should make preparation for the emergency materials in advance and take emergent actions quickly and effectively. Whether under the internal or external disaster emergency rescue work , the rescue materials are of great necessity. During the earthquake emergency rescue, the relief materials, which are the most basic to support the rescue, need to be prepared in advance and be handy at any time. If these relief supplies are prepared

after the earthquake happens, it will may delay the rescue [7]. So far, there has not been any large reserve relief in Jiangsu . The nearest one in Yangzhou is only medium-sized . there is no large scale disaster relief materials reserve base in Taizhou and the relief supplies are decentralized and reserved. So that the civil affairs department is responsible for clothing, tents and other life relief materials like reserve medicines, medical equipment, vehicles, food and other relief supplies which are provided by the medicine and health care, transportation and food department. In addition, the number of warehouses is relatively small, warehouse management and logistics equipment is relatively backward and the materials handling mechanization level is low ,so it is difficult respond quickly to major disasters. All lead to slow transmission speed in the disaster relief, material supply, inconvenient coordinated transportation and unstable demand for vehicle . the cost of providing disaster relief is high. Great attention should attached to how to ensure the emergency co-ordination and the minimum loss is of vital significance, so the government should strengthen the reserve and management of emergency supplies in Taizhou .

III. THE CONSTRUCTION OF TAIZHOU EARTHQUAKE EMERGENCY LOGISTICS SYSTEM

This paper holds that the earthquake emergency logistics system in Taizhou should be improved by the unification of the government and people from all walks of life. We should ensure the security and arrange the distribution of relief supplies according to the actual demand of the disaster and soon restore the normal order logistics system which is shown in Chart 2. Taizhou earthquake emergency logistics system consists of the resources guarantee system, the reserving personnel security system, the information exchange platform system, the emergency logistics distribution system and the operation system.

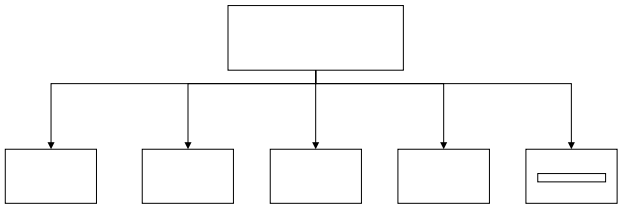

Fig.2 Taizhou emergency logistics management system under earthquake disaster

3.1 The construction of earthquake emergency logistics resources guarantee system

The smooth implementation of earthquake emergency logistics is based on the effective support from all resources guarantee systems of the whole emergency logistics system in that the emergency logistics resources guarantee system presupposes the implementation of emergency logistics. According to the design of Taizhou (2010) in the "Emergency Resources Allocation Mode of Emergency Resource Allocation" by Zhang Nian, the earthquake emergency logistics resources guarantee system is shown in Chart 3.

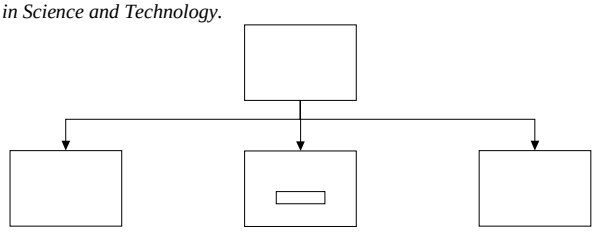

Fig.3 Resources security system for emergency logistics

3.2 The construction of reserve personnel security

It is a certain fact that the practical emergency logistics professional technical talents are badly needed in Taizhou currently. Talent shortage, to some extent, hinders the development of the emergency logistics in turn. If only relying on fire protection, public security departments, it is far beyond the need of quality and quantity. Therefore, the development of emergency logistics can meet the development of the society provided that the special talents of earthquake emergency logistics are fully developed. Therefore, this paper constructs reserves personnel security system as shown in Figure 4 [8,9].

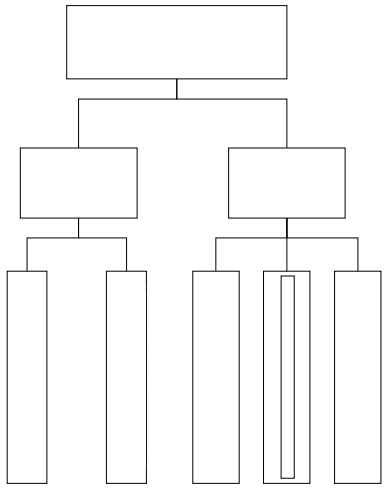

Fig.4 Reserve personnel security system

First of all, all colleges and universities in Taizhou should follow the market demand and its own advantages, establishing logistics management (emergency logistics professional direction) professional and through the introduction, training and other measures as well as quickening the pace of team construction.. Through the reasonable orientation, the all round emergency logistics professionals are not only trained as operation personnel for enterprises, but also cultivated as the senior researchers for the enterprise. Secondly, a large number of excellent emergent logistic talents should be introduced to large-scale enterprises so as to strengthen and enrich the current guidance and management of emergency logistics , thus speeding up the construction of emergency logistics system in the entire city. In the long run, outstanding talents should be sent to leading enterprises and top universities at home and abroad to take in advanced technology and bring back these rewarding experiences. The talents and personnel should be trained in a multiplied and diversified way.

Finally, it is worthwhile that the government can encourage the senior management personnel of relevant departments and enterprises to introduce emergency logistics from abroad logistics from abroad or emergency logistics engineering and technical personnel to be in the policy, and to offer better rewards in order to sustain the development of logistics personnel.

3.3 The construction of information exchange platform system

As the earthquake is very destructive, in the case of unavailable GSM network and Internet, information platform for the information tracking should be constructed combined with computer network technology using GPS, GIS, RFID technology to shorten the working process and make the transmission of information more reliable. Open hardware can not work without the support of the information system in the implementation of support. This paper designs the information system. According to Wang Wenliang (2003) in the "emergency logistics information system construction" and Xie Ruhe (2005) mentioned in the "on the construction of emergency logistics system and its operation management" in the construction of emergency logistics information system of ideas, the construction of the information platform for the earthquake emergency logistics is shown in Figure 5, the pointed direction represents the information flow direction. The arrow refers to the information flow .

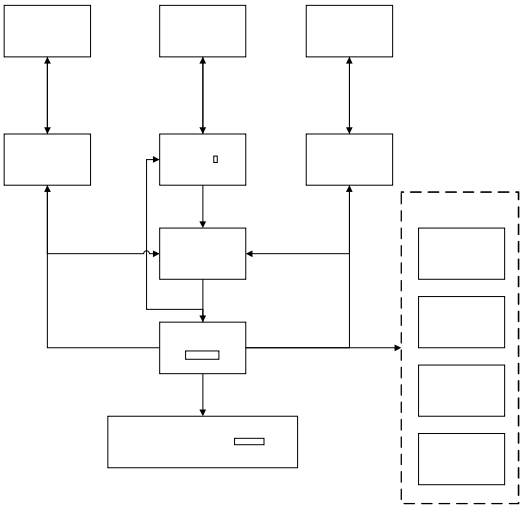

Fig.5 The information platform for the earthquake emergency logistics

The platform can keep a real time contact with the earthquake disaster in the city emergency logistics command, civil affairs, health and epidemic prevention, environmental
protection, meteorology, traffic departments, so as to grasp the relevant information, and maintain the dynamic supplement and update data continuously. Based on the system as the support and the platform of information, the government can release announcements and emergency regulations timely and precisely, as well as update the disaster, weather, traffic and so on, thus informing the public get the most reliable disaster information [5].

3.4 The construction of emergency logistics distribution System

Emergency supplies must be timely and accurately sent to the disastrous areas which will need the support of the formidable emergency logistics distribution system. This paper presents such an efficient emergency logistics distribution system in Figure 6.

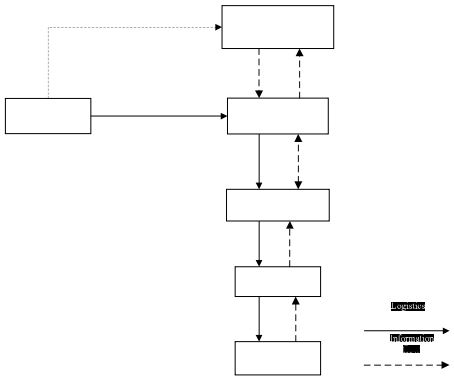

Fig.6 Emergency logistics distribution system

Distribution center is in the event of natural disasters in the disaster area and the surrounding area after the establishment of the temporary transit point its functions include receiving and sending relief supplies management all around, and turnover, deploy and assume the functional needs of information exchange. It will be a disaster relief center in the scene to obtain the material demand and reserve center for exchange, and it is convenient to make decision by the feedback information platform and the emergency command center.

As the third party logistics shows its distinct advantages in integrating resources, speeding up the supply and optimizing the processes incarnate its unique advantage in the emergency logistics, the construction of earthquake disaster emergency logistics system should be taken into consideration.. To maintain the highly integrated system and optimize the highly logistics resources in the emergency logistics system, the third party logistics professional advantages in the integration should bring into a full play, so that the entire disaster emergency logistics system becomes more reasonable.

3.5 The construction of earthquake disaster emergency logistics operation system

When displaying its function to transfer material, sufficient material reserve, two-way information exchange, good commandeer and fast delivery are needed to deliver goods and materials at maximum and within the minimum time to the needed areas. This paper proposes that emergency logistics operation system should consist of four parts, as is shown in figure 7.

Emergency materials raising system shows the source of emergency materials, including emergency supplies which are the most direct after the earthquake happens. Therefore storage should be classified according to the type of storage information of emergency material demand forecast, and ABC method is adopted to manage the inventory; emergency procurement and temporary purchase in line with temporary procurement, production planning of

earthquake disaster information, which is key to control the disaster and reduce the loss; Emergency rescue accepts all kinds of donations from individuals, national and international organizations and associations.

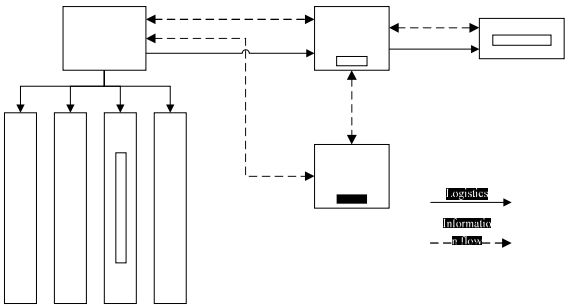

Fig.7 Emergency logistics operation system

Raised emergency supplies need to be drawn up detailed plans to deliver timely and distribute timely, as well as employing the technical means to track the whole dynamic process. This requires emergency logistics scheduling system to complete the above functions. Center based on the emergency logistics command department instruction, sends the instruction information to the raising system and distribution system in logistics center, join logistics enterprises and other organizations, it can supervise these organizations to do timely logistics operation preparation, allocation of capacity reasonably, and require these organizations to give real-time feedback information. It also can find problems in two-way transmission of the information, and take measures to ensure the timely delivery of relief supplies without delay.

Emergency logistics transportation and distribution system need to send the materials to the disaster areas as soon as possible, making full preparation for effective distribution. [6]. Emergency logistics operation system would plan the emergency logistics distribution network scientifically in accordance with the earthquake disaster. By means of the computer and the GPS to find the optimal distribution route, according to the self built database and FIFO principle establishing the best inventory and planning the reasonable configuration distribution so on, simplify the intermediate links and reduce the service of goods and materials in transit time each rescue, and then distributed by the disaster scene all kinds of rescue workers to the affected people.

Emergency logistics information system coordinate in emergency supplies between system, emergency logistics scheduling system, emergency logistics distribution system and rescue point, it guarantees that the demand distribution information timely in the normal transfer between the various functional departments, and give reference for the command center of decision making.

IV. THE EVALUATION OF TAIZHOU EARTHQUAKE EMERGENCY LOGISTICS SYSTEM

Earthquake is destructive, paroxysmal, persistent, and urgent, for which the operation system of the earthquake is greatly influenced. Therefore, it is necessary to evaluate the existing earthquake emergency logistics system. This paper attempts to adopt hierarchy analysis to the evaluation of earthquake emergency logistics system, and tries to find out all kinds of influencing factors in the operation process of emergency logistics system and constantly enhance the operation ability.

4.1 The establishment of evaluation index system of earthquake disaster emergency logistics capability

According to the emergency logistics system constructed in this paper, emergency logistics system is composed of four aspects, namely, the resource guarantee, information exchange, emergency logistics distribution and operation system [10,11].

Therefore, the evaluation is indexed from four aspects, namely, the organization and coordination capacity, storage capacity, distribution ability and information processing ability in the construction of emergency logistics system all of which are affected by diverse contributing factors which are shown in table 3.

Table 3 The evaluation index of the operation ability of the earthquake emergency logistics system

Top floor	The middle elements	The underlying factor
The operation ability of earthquake disaster emergency logistics system of P	Organization and coordination ability of P1	Leadership decision-making ability of P11
		Dispatching ability of P12
		The mechanism operation ability of P13
	The storage center capacity of P2	Materials raising ability of P21
		The rationality of the layout of the P22 storage center
		Emergency materials inventory capacity of P23
	The capacity of distribution logistics P3	The rationality of P31 distribution line
		Distribution tool suitable for P32
		Optimization of distribution of resources by P33
	Information processing ability of P4	Earthquake monitoring and prediction ability of P41
		Information mutual ability (information patency) P42
		Information feedback to evaluate the ability of P43
		Information decision ability of P44

4.2 The evaluation of emergency logistics capability evaluation system of earthquake disaster

This paper adopts AHP to evaluate operation capability referring to the earthquake emergency logistics system of the city. AHP, as a practical method for making a quantitative analysis in qualitative event and sorting the results, make clearly how the different contributing factors account for. The method combines systematic and hierarchical analysis with little information. The decision is made in such short time that it is not only very suitable to evaluate the emergency logistics capability but also helpful for decision makers to find the optimal emergency logistics system in a short period of time[12].

According to the evaluation index of the operation ability of earthquake disaster emergency logistics system by YAAHP, the hierarchy diagram is shown in Figure 8.

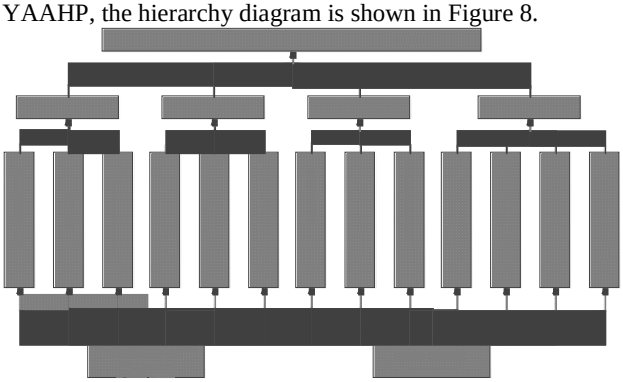

Fig.8 The hierarchy diagram of the earthquake emergency logistics system

This paper conducts the evaluation and analysis by using the earthquake disaster and the construction of the emergency logistics system as Plan A, , or the existing earthquake emergency plan in Taizhou as Plan B. Judging which factors are relatively important from the earthquake disaster can make more contribution rate for enhancing the operating efficiency of emergency logistics system. The paper makes a comparative analysis between the newly proposed system in the paper and the existing emergency plan by means of YAAHP software,.

In light of using brainstorming, this paper draws two sub comparison matrix of the earthquake emergency logistics system.

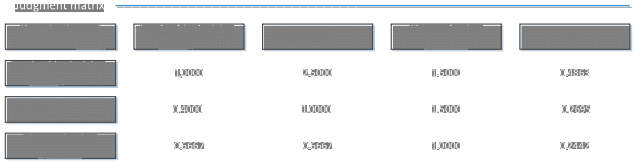

Fig.9 Comparison about the importance of the organization and the coordination ability

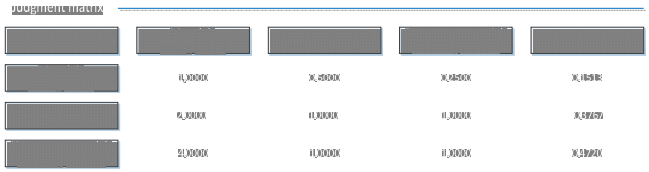

Fig.10 Comparison about the importance of the storage capacity

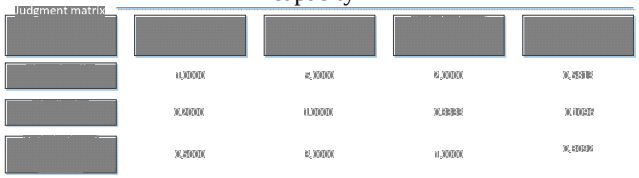

Fig.11 Comparison about the importance of the logistics distribution

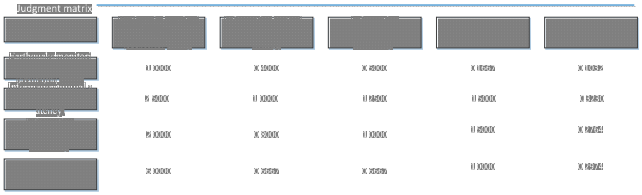

Fig.12 Comparison about the importance of the information processing ability

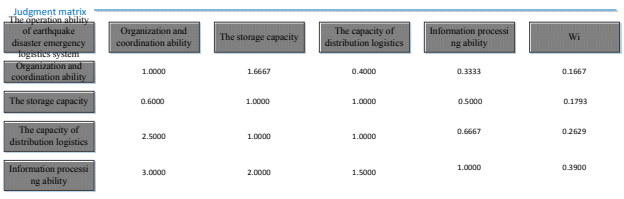

Fig.13 Comparison about the importance of the operation ability to the emergency logistics system

All the contributing factors can be weighed and calculated through software calculation

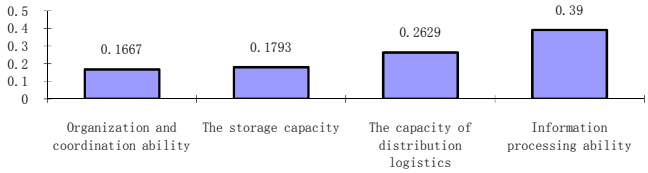

Fig.14 The weight ordination diagram to the operation efficiency of the emergency logistics system

Here are all the affecting factors of the second layer element weights diagram.

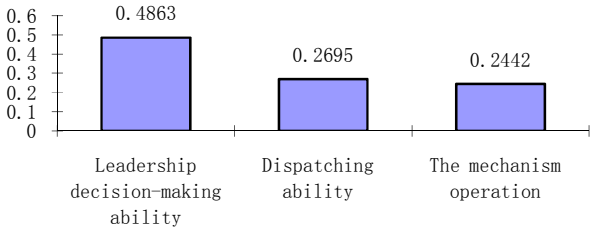

Fig.15 The weight ordination diagram to the organization coordinated ability

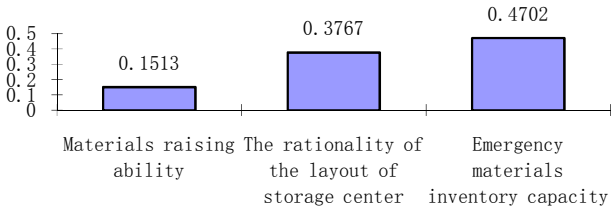

Fig.16 The weight ordination diagram to the storage capacity

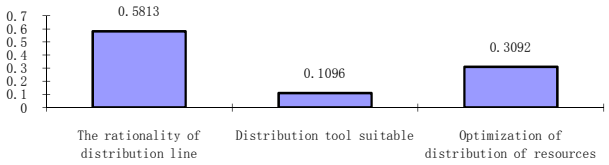

Fig.17 The weight ordination diagram to the logistics distribution capacity

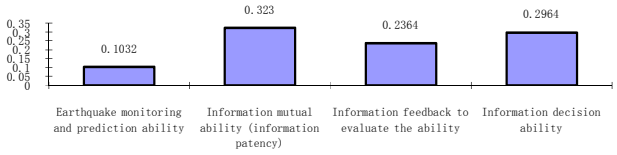

Fig.18 The weight ordination diagram to the information processing capacity

Thus, the weight regarding with the operation efficiency of earthquake emergency logistics system can be shown in table 4.

Table 4 The total weight sorted list for the operation efficiency of emergency logistics system

A level influence factors	Two level influence factors	Weight value	Total weight value
Organization and coordination ability		0.1667	
	Leadership decision-making ability	0.4863	0.0810662
	Dispatching ability	0.2695	0.0449257
	The operation ability of organization	0.2442	0.0407081
The storage capacity		0.1793	
	Supplies ability	0.1513	0.0271281
	The ability of emergency material library	0.472	0.0846296
	The rationality of the layout of warehouse centre	0.3767	0.0675423
The capacity of distribution logistics		0.2629	
	The rationality of distribution line	0.5813	0.1528238
	Distribution tool fit	0.1096	0.0288138
	Distribution optimization of resource utilization capacity	0.3092	0.0812887
Information processing capability		0.39	
	Earthquake monitoring and prediction ability	0.1031	0.040209
	Information mutual ability	0.323	0.12597
	Information feedback and evaluation ability	0.2764	0.107796
	Information decision-making ability	0.2974	0.115986

It can be seen from table 4 that rationality of information delivery route, information feedback ability evaluation ability and information decision-making ability play an important part in the emergency logistics system though there is uncertainty about earthquake disaster. yet each department can make the adequate preparations for the transmission and feedback of information.

According to the data obtained by YAAHP software, in order to achieve working ability of the emergency logistics system, the city earthquake emergency logistics system constructed in this paper surprisingly gets 73.91 points, while the original one only gets 26.09 points. Under the same target, the emergency logistics system constructed in this paper bears better operation ability suitability for current informative, integrated and collaborative emergency logistics development.

V. CONCLUSIONS

This paper studies the problem concerning construction of earthquake emergency logistics system in Taizhou. It begins with the theoretical foundation of the construction of emergency logistics system and then finds out the deficiency of the current Taizhou city in response to the earthquake disaster emergency logistics system aspects; and then it constructs the framework of emergency logistics system in Taizhou City, and gives the detailed measures to the construction of earthquake emergency logistics system from the organization coordinated ability, storage ability, logistics and distribution capacity, information processing ability four aspects ; Finally, it uses the analytic hierarchy process to construct the evaluation model of the operation ability of emergency logistics system and evaluate the earthquake emergency logistics system.

To make the emergency logistics system bring into a full play, it is not enough to rely only on the construction of system. We should make joint efforts to solve the problem timely and effectively.

(1) Strengthen executive power;

(2) Improve the hardware construction work on the emergency logistics information processing system

(3) Ensure the transportation security work;

(4) Enhance the flexibility of the system.

Although some researches have been conducted in relation to the construction of earthquake emergency logistics system in Taizhou. Yet some problems need further study. For example, how to optimize emergency materials transportation path in emergency material distribution process and how to optimize the path and navigation system and information system interconnection. A lot of practical researches are still required.

So far, the emergency logistics system in Taizhou has not been perfect which still needs to be strengthen its theories and practice. The talents should be developed further in order to make this system mature. With the development of informationized society,the emergency logistics system can show its social value in a better way and will play an increasingly important role in dealing with the earthquakes.

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