ABSTRACT
From the reform and opening up in 1978, China’s construction industry started a new development. Adopting new ways of construction management, decreasing the cost of buildings, promoting high efficiency, in a word, a lot of changes occurred in China’s construction. But, progress does not mean success. Development goes after permanence. When we talk about the achievement in China’s construction, we can not ignore the problems which puzzle us for some time. The problems as follows: too much manpower, inadequate mechanization, wastage of materials, even rear ones, too much repetition of the same project and less profit for the corporations, etc. This paper tackles three themes related to these problems. The goals are to develop sustainable construction management and to achieve this by using information techniques. The paper argues that the two goals will be achieved by promoting large-scale corporations.

Keywords: Construction Management, China, Sustainable, Information

1. THE SITUATION OF CHINA’S CONSTRUCTION INDUSTRY
China’s construction industry is now in a very important period, full of changes and challenges in a transition from tradition to modern practices.
Especially after 1978, the year when reforms in and opening-up started, the construction industry developed fast, contributing to the growth of related industries, making a great contribution to China’s GDP, exerting itself to mitigate unemployment or lay-off, promoting urbanization process and so on. Frankly, due to the close association with other industries, it has been a leader towards more sustainable and stable economy. In fact, in the coming time of globalization and information industry spreading in all regions of society, almost all the construction companies, native and foreign, bigger or smaller, have been searching for an efficient way to take up a position or to
infuse them into new vitality in competition now and the future. Some of them may be compelled, but no choices. From this view, compared with advanced companies in the world, there is still a long way for China’s enterprises to catch up with them, not in the fields of equipment and facility, but the management and mentality.

At the mention of that, I have to recall the old days in the early time of 20 century, China and Japan government of that time sent a lot of students abroad to Germany to learn advanced technique and mentality in order to change two countries’ behindhand development situation. In Germany, nearly all Chinese students chose to study their applied skills, just like shipbuilding, chemistry, pharmacy, est. Oppositely, Japanese students were more interesting in German ideology and thoughts, including Kant’s philosophy, political ideas and so on. At that time, the emperor of Germany forecasted the future of the two nations — the advanced technique versus the advanced ideology. As a result, Sino-Japanese War of 1894-1895 showed all. China lost completely. So referring to China’s construction enterprises, if one is not think about how to achieves scientific ways and means of construction management, how to reduce the cost of the whole project, how to enhance the work efficiency, that could be evicted early or late.

1.1 Economic situation

Since the reform and opening-up in 1978, China’s construction industry has changed a lot, especially in its GDP contribution. As the table 1.1, with the fast national economy increase and the advance of investment rate of fixed assets, China’s added value of construction industry raised annually, from 4.26 in 1981 to 6.26 in 2005. Further more, the development of construction industry promotes other industries' innovation. For example, the property is one of the direct beneficiaries in the last 10 years. Due to its fast development, China’s urbanization, especially the growth of large- and medium-sized cities is a great concern about it. In addition, its effect in employment should also be taken into account. In 1981, there were in all 10.58 million practitioners in this industry, compared with 38.93 million in 2002. In fact, the most important is that its total production value is up to 1869.6 billion RMB. Relating to that the revenue from construction industry increased rapidly. Starting from 1992, its speed of going up is 30% per year. In conclusion, the construction industry plays a very significant effect in China’s economic development.

Although the economic situation shows China’s construction has huge development potential, but its economic efficiency is not like that. Now China’s construction enterprises complete 1500 billion quantities annually, which is the most in all over the world. But the productiveness and benefit conditions are worrying obviously, for instance, China companies’ capital margin does not reach to the half of Japanese ones. And that the quotient in
international construction market of its corporations is less than 2%, which is disproportionate with the development scale of China’s construction industry.

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate of fixed assets investment (%)</th>
<th>Proportion of added value of construction industry in GDP %</th>
<th>Amount of practitioners in construction industry 10,000</th>
<th>Practitioners in construction All practitioners (%)</th>
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<tbody>
<tr>
<td>1981</td>
<td>19.76</td>
<td>4.26</td>
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<td>2004</td>
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At last, due to the excess budget, reduplicate construction and delay time on account of unqualified design and unscientific management, the waste in construction is egregious. Based on English statistic, if one nation’s construction industry completes its modernization process, the cost of it should be decreased to 70%. But now the upkeep in China is still up to 600 billion RMB a year.
1.2 Manpower situation

Frankly, the fabric of practitioners in China’s construction industry is not suitable. Based on the Stat. in 2001, there are 35.52 million people employed in this industry and most of them are construction workers with less knowledge and scientific skills. The managers, technician and engineers only take a weak position. All of them form a pyramid type structure, with the 25 million workers in the infrastructure, compared with 5.34% advanced technician 4.92% managers and engineers in the top. Relative to the construction workers, only 3.1% of them have accepted the skill training. The others are labour force in the country, having no relative necessary skills and knowledge, no essential training and instructions, which are both the reasons of construction accident. And for the advanced technician, there are still a lot of differences compared with the ones in developed nations. Educational level is the priority. But China’s Ministry of Construction regards this one as a very important problem. To establish the training centre, set up many relative majors in the campus, compile and publish a lot of catena, in a word, promote the improve of man power in construction is the vital task of it.

Especially in construction management, from none to much, China’s construction management is now in a high developmental way. Because that more and more managers graduate from professional colleges. Now plenty of universities have established new research centres or relative schools for construction industry.

2. CHINA’S CONSTRUCTION MANAGEMENT

What is construction management? That is the key problem, which needs to be clear and definite firstly. The knowledge system of project management (Project Management Body of Knowledge, PMBOK, 2000.10) produced by Project Management Institute (PMI) divides this item into 9 knowledge realms, namely the scope management, time management, cost management, quantity management, human resource management, communication management, purchase management, risk management and synthesis management. Based on this mentality, we could define the four important phases in construction management:

- Process management: construction management is a kind of process management, which regards the time and value as guidelines, to ensure the project complete with the least amount of cost or effort.
- Time management: it shows that the construction management is dynamic, continuous and timely.
- Cost management: budget, final accounts, capital movement, all of that are nearly relating to a project.
- Quality management: due to the buildings’ security and stability, the quality should be the priority in all the work.
China’s modern construction management originates 80's of 20 centuries, being as a branch of modern management science. It is introduced into China in 1982, Soon application as the experimental unit in 1988. Since 1993, construction management has been promoted in the whole nation. Along with China’s reform and opening up deeply, the construction management develops fast accordingly. Contractors and owners have already accepted it widely. More than 100 world’s famous construction companies have successively came to china’s market. In them there are a lot of contractors of PMC in vital projects.

Now, there are the main ways of construction management in China:
1. The owner set up PMT to carry through construction management.
2. The owner invites PMC to carry construction management into execution.
3. The contractor engages professional construction management institution to manage in order to get the maximum benefits.
4. Because of the little project, the owner often regards itself to be the construction manager.
5. The projects that the governments invest in are still managed by government official.

![Diagram](image)

Although there are many ways of construction management in China, but the model like Figure 1.1 is the most popular type nowadays. If the project is not big enough, the owners often prefer to establish a PMC by itself. So that it can directly express the owners’ meaning and control the whole project. Because of that, the PMC could not perform independently, and more to exactly dominate the budget, abide the time, ensure the quality. Actually the construction management mode and concept are placed in the “mixture district” now. One hand along with China’s reform and opening up, the traditional construction management suffers the abroad ones, especially referring to external affairs; On the other hand, the domestic ones stay
around the traditional mode. Because China still use the traditional construction mode, so that the plan-management departments, material departments and financial departments are separated but not a whole, which is hardly reach to unify in a short time due to their systems independently with work method. How to transfer the existing frame to accommodate time’s calling, reform construction management in China may be an efficient way.

2.1 Opportunities and challenges

China expect to realize complete well-off society in more than 20 years in the beginning of this century, to realize becoming more prosperous, rich and strong, modern nation with democracy and civilization in this middle of century, which is the big key in development of the construction management. Sustainable development is the common principle of 21 centuries in China and also the basic national policies, it should be a guarantee that the economy could be positive to develop.

Through reform and opening up, China display more prosperous. Socialism and economy have developed with high speed and health. At the same time, the high speed of increased investment, consume and export, the more require for housing, cars, education, health, and information, are the new impetus in China's economic development. The whole world pays much attention on China’s huge market produced by the high speed of the national economy and the large-scale of modern society establishment. Continuous added value of GDP shows that China is to put in a fast way for every industry that means a great chance for construction industry. For these years, China’s economy growth rate are all up to more than 7% with the growth rate of fixed investment up to 12%( far higher than the one estimated by United States round-the-world's observe for the investment of other 55 markets around the world), which shows the great need of the construction management as PMC or EPC in China.

And China’s investment environment is good. For many years, China is always one of the countries that get the foreign capital most. For a long time, China have plenty of big project, for example, what are being proceeding, The West Development, The Western Region Spirit East Lose, The West Electricity East Sends, The Middle Route Water Transfers Project from South to North The Railway in Qinghai and Tibet, The Olympic Games in Beijing, The World’s Fair in Shanghai Transportation Developments of Shanghai, The Living Creature Environmental Protection, The City And Country Charged Barbed Wire Net Reforms, The Northeast Industry Construction Adjusts to Reforms With Technique, among them there are enormous opportunities of the construction management.

2.2 Advantage and disadvantage
Frankly, the market of construction management in China is extending now. Based on the statistic in 2004, the amount of companies participated in construction management is more than 300, with 2 billion RMB taking. In it, the company with most taking gets 60 million RMB. Otherwise, based on the statistic from China, in 2003, there are in all 40 enterprises achieving more than 10 million RMB taking, with the most one up to 0.27 billion RMB.

Not only the high taking, but also the manpower shows a very good progress. As we all know that construction management is not the same as single management, just like site management, design management, stock management and so on. It allows practitioners to familiar with construction skill and also the organization system of the construction, in addition, all works relating to construction. Through many years practice, China has cultivated a lot of personnel who are competent for this work now.

But, we all know that construction managing knowledge is becoming more and more important within the construction industry, because it is considered critical for the competitiveness of a construction firm. Managing knowledge is particularly important to the construction industry due to the unique characteristics of its projects such as multi-disciplinary teams, temporary team members, heavy reliance on experience, the one-off nature of the projects, tight schedules, limited budget, etc. But due to the late development of China’s construction management, there are a lot of textbooks published by international presses, with the knowledge frame and language not suitable for Chinese. After all the economic system of China is not the same with other nations, which shows that the regulars and operating system are different. That allows the national training and education ways for China’s relative human resource cultivation.

Secondly, China has no normative construction management system, so that every company has a kind of it, which leads to a confusion in this area. At the same time, due to its different criterions, it is hard to estimate any enterprise, and also difficult to measure the achievement of them.

3. THOUGHTS ABOUT CHINA’S CONSTRUCTION MANAGEMENT

Development goes after permanence. When we talk about the achievement in China’s construction, we could not ignore the problems puzzled us in a long time. How to solve the problems as follows: Too much manpower and labour force, inadequate mechanization, more materials even the rare material wasting seriously, more reduplicate buildings and less profit of the corporations, est. there are three thoughts about China’s construction management. To establish sustainable construction management is the guidelines, and it should be realized by the application of Information technique. At last to promote large-scale corporations is the guarantee of the two goals above.
3.1 The realization of sustainable construction management

The evolution of the concept of sustainable development is used as a basis for advancing understanding of sustainable construction. Principles of sustainable construction are developed and divided into four 'pillars' - social, economic, biophysical and technical - with a set of over-arching, process-oriented principles, to be used as a checklist in practice. In fact, sustainability means a thought that the world and resource we are sharing now should be shared generation by generation. From this view, every industry should make sure its details in professional regions in order to constitute relative regulars for the aims. In China, more and more people know the concept of sustainability; realize the mentality of sustainable life. In its construction industry, clear goals about sustainable development are promoted by kinds of relating to administrations and enterprises. For the content, the highlight is a multi-stage framework is proposed which requires the application of Environmental Assessment and Environmental Management Systems for construction projects.

It is known to all that the object of sustainable construction management (Supply Chain Management) is not itself, and relating to some micro- and macro- environments around it. That means when we carry through Supply Chain Management, we must think about the influence produced by the project and use scientific ways to reduce the negative affect. In details, it allows us to integrate the project goals, environmental goals and economic goals to a whole under the coordination of nature, human being and societies. Based on that, the owners, contractors and managers ought to make a great cooperation in every step of the construction. In addition, with the development and progress of the society, a lot of advanced techniques and equipments occurred in our life, which could be used in construction firstly to ensure the sustainability. For example, the Internet is able to enhance the speed of information transmission, from the other hand, also could reduce the paper use.

Especially the usage of Enterprise Resource Project and Customer Relationship Management may accelerate Supply Chain Management development with its influence in organization changes. So the Supply Chain Management is a kind of approach that puts construction management in a
big society circumstance, using advanced skills to ravel environmental problems out in order to ensure the sustainability of the construction industry.

The factors relating to Supply Chain Management are more as follows: economic performance, utilization of resource, improvement of construction, environmental condition of projects and so on. Surely, the Supply Chain Management is still affected by the policy, laws and regulars of the nation.

Among them, the government as the supervisor, the most important, the representative of people’s benefit, should enhance its command and function for the sustainable actions. At the same time, all levels of administration should start the “Society Assessment” to insure the construction models being propitious to sustainability. In addition, the government may use economic ways to encourage enterprises that do a good job in Supply Chain Management compared with a heavy punishment to the anti-ones.

And for the project, Supply Chain Management to them is a new concept to organize the whole construction. To the material, the sustainable and recycling ones should be taken into account firstly. To the site management, it allows contractors to try their best to reduce the noise, to low the letting of exhaust gas, liquid waste and waste residue, to avoid unnecessary damage to the environment. To the owners, contractors and managers, Supply Chain Management may increase the cost of the construction. But it could compensate them on another side, to ensure their sustainable life. And for the users of the project, there are more to say. Due to the function of every building, the users of them in application should choose a sustainable way to maintain them, ensuring the cast-off closing off, reducing the quantities of resources and recycling much rare material.

3.2 The application of Information technique

What is information technique in construction? Project Management Information System may be the best answer. If we could explore a software replacing people’s position to control the whole construction, to reflect the process and to support many data analysis, that should be the actual expression of it. Now in the world, due to people’s intelligence and wisdom, there are many familiar system produced by us, just like P3, Microsoft Project EST.

Experience and research in 20 years shows, China’s construction has established gradually a whole management system which is connecting the nation with the world, also matched the china’s construction. But on the other hand, it is very low level for us to mange the projects effectively through the information technique and also hard for us to collect effective information in the project. How to get it and deal with them timely and scientifically will be the key problem of China’s information application in construction area.

In the last few years, many enterprises of china started to reform the process of construction management in order to realize innovation. Plenty of
capital and manpower were devoted to establish relative organization to execute this project. But the result was not sure; at least do not attain established goals. In fact, among all the system from aboard, there are only a few ones achieving close joint with China’s condition. Others obviously express unsuitable in organization system, checking ways and operation habit. May be some software for technique application, compared with ones for management, are useful and obtain quite good promotion, just like CAD and so on. Other software or systems are not so lucky. So as to some acid saying: "the ENTERPRISE RESOURCE PROJECT which puts succeed in others do not suit China", "foreign software is not acclimatized." It is an actual example for this. There is a project in china valued near ten million in investment that cooperates with an abroad management company to develop a PMIS. The function of the system is advanced and complete, but now only 20% function being using.

What is the reason of that? On one hand, the obstacle in management system and behaviour influences it. On the other hand, the blindfold chosen of the MIS and the weak integration of the soft wares lead to a low efficiency of them. As for the majority project management software, the most outstanding problem is the less degree of integration as follows:

- The standard regulars for information shared do not achievement, which is the main reason of information movement. Island of information exists widely. Inconformity of the public fundamental data code leads to the inconsistent of the data in every kinds of software. The connection of any data is not enough.
- The owner’s data is not concentrate with the contractor's data. The data occurred in construction, managers and project management is independent, so that the cost of the information transmission is higher.
- The accuracy and integrity of the database need to be kept timely.
- It is hard to realize the transfer of the content and ways of databases from construction to production.
- The workload of the further improvement in software outruns the current information technique power a scope for can acceptance.

In fact, because of the complexity and variability of the construction, it is hard to define and classify the information, especially that some information still needs to be turnover among owners, contractors and construction managers, which is not easy to reflect all information to be in one platform, and also difficulty in finding out an united standard to measure each information. The actuality of China’s construction management reflects a common problem like that. How to integrate the information from the owners, designers and managers, establish a timely supervising for the construction quantity, cost, progress, contract and supplies equipments, is the key problem. Referring to this, the first and also the most basal is to define every kind of information taken place in the construction clearly and exactly.

If we investigate carefully the process of the construction management, it is not difficult to discover that the management for a large- and medium-
sized complicated project is actually a domination, using the resources (manpower, tools, material, funds, work period) that we have to realize an aim (progress, quantity, expenses) through comparing planning and actual process of the construction in order to adjust and control the whole one effectively and exactly to get the great goal— least devotion to best performance. Among them, the plan of construction management takes the most important position in a project. Otherwise it is also the holistic leader, for that other management works are all around it.

Based on that, How to realize a good construction management lies on a perfect plan. But we could not only depend on the planning, because if there is not an effective planning execution and monitor working in with them, the best plan means none. Therefore, if we establish a system to reflect the contrast timely between actual work and planning, the construction management could become effective and easy. In fact, that key is not difficult to realize, the most significant is to affirm every piece of information in the construction management, which is also the approach for us to know the differences between actuality and plan. In addition, there is the need for owners, contractors and other ones relating to the project to know the process and to communicate with each other. Figure 1.3 is a sketch map of this thought. Please pay much attention; the central concept of this figure is that two axes fix on one point, one piece of information.

This platform regards the construction Work Breakdown Structure (WBS) as the foundation. The X-axis and y-axis are divided into two parts.

In it the X-axis means the management functions, being divided into construction organizations, construction plan, construction finance, and construction resources. The Y-axis displays the stages of a construction, referring to foundation and base, main body, installation, decoration, environment the etc. The two axes compose a platform for integration of information in construction management. Based on that, we could know that every piece of information in construction connects with the two axes, maybe belonging to one of the X-axis module or Y-axis module. That is also convenient for us to see the headstream of the information to deal with it through relative departments. Otherwise, it is also a platform to gather owners, contractors and managers with the same information shared, just like cost, time and resource.

As the contractor's view, the implementation of the construction management information system can reduce the workload that drawing up plans, accumulating project process data, establishing relative management systems and so on. It also could promote the enterprises to change the type of the management. Although in different management mode, the obligation and right of the owners, managers and contractors are different. But viewed from the whole process of the management, the whole frame is the same in accordance with working the contents.
3.3 The promotion of large-scale corporations

The amount of companies, which have the international competitive ability, is small. Now in China only a few of big corporations relating to some monopolization regions, just like petroleum industry, chemical industry and so on. Especially for the international business, almost all of them operated by foreign companies. In USA, the one year’s total taking of a company is 13 billion dollars, compared with China’s benefit of all foreign construction annually 8.9 billion dollars, which shows a great difference between two nations in international business of construction industry.

At the same time, China’s national enterprises who get into ENR rank in the world are only 34, with the international taking 4.8 billion dollars a year. This taking is less than 65% of taking of that company in USA. China’s practitioners in construction industry are 4.5 times of relative ones in USA. But the annual production value is USA’S 20% with the Japan’s 1.25% productivity. In China’s national market, the productivity is not up to one in three of electric industry. Because the productivity is a important index which shows the vitality of a industry, so China’s construction industry is still not a modern one from the world’s view. In addition, China’s scale of construction enterprises is 35 times than the ones in developed nations, but the production value is not corresponding with its size, which display a scene that “big but weak, more but poor”. In China’s construction industry, the advanced techniques are rare in enterprises. The ordinary condition is that: the little amount of patent skill, the low application of technique, the lack of new concept, new mentality, new exploration and usage. A lot of companies depend on their adequate manpower to offset them.

How to enhance an enterprise’s ability of competition is a big problem relating to sectors mentioned above. There are two ways to realize. One is
personnel's training, which is the fundamental work of it. Now in China, many universities and colleges start their characteristic courses to reply the market's need. It often has two kinds, the short terms for temporary workers or staff to being familiar with the industry, to get the basic craftsmanship, the long terms for formal students to learn it as a science. Of course, it also has high levels for professional managers or senior technicians for their further research. The other is to integrate the recourse of enterprises in order to set up new, big corporations to suit international challenges. In this sector, it is advisable to optimize all kinds of companies, especially the ones with different predominance. Some little enterprises often have technique advantage, but lack of competitive competence. Compared with them, there are enough manpower, capital and connections in big corporations, but lack of agility and sensitivity. Owing to its big scale, it is slow for the market changes and technique renovation. It often loses opportunities in international competitions. In a word, China needs to set up a kind of big corporations, much smaller, more effective, always leading the tendency, focusing on the future for ever.

In the process, China's companies should pay much attention on the exploration of relative software. To the small ones, it is convenient to introduce international advanced software into practice. Referring to the big ones, it is great for them to devote their attentions, relative manpower and capital to create a kind of national operating system, which is much suitable for China's condition and characteristic.

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