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State Of Art Of An Optimal Scheduling Model For Ready Mixed Concrete Plant

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Abstract— There are tremendous growth in the use of ready-mixed concrete (RMC) for construction in developing countries. In India, the production and use of RMC is now widespread, but the quality of concrete construction is still generally drawback. The RMC industry is not updated. This has contributed to a general disregard for the basics of good quality. To identify and rectify the situation and to improve the performance of RMC producers, systematic monitoring and inspection is required. Recently, the developing countries have started implementing a quality scheme for RMC plants operating in the cities of developing countries. The scheme was designed considering the difficulties and constraints common to implementing a quality scheme in developing countries. This paper give details of the quality scheme as developed for RMC in Madurai, India. Specifically, the scheme objectives, its elements, as well as the major difficulties and challenges encountered during its development and implementation are specified and discussed. This scheme impact on the performance of RMC producers and the quality of ready mixed concrete produced during the past years are presented. The implementation of the scheme has resulted fine improvement in all aspects of RMC operation and product quality. Based on the experience and progress achieved so far, it can be concluded that quality scheme can be introduced successfully into the existing RMC industries in developing countries with immediate benefits to the industry and its customers.

Keywords: Ready mixed concrete; Scheduling; Truck dispatching; Network; Overtime

I. INTRODUCTION

Ready mixed concrete (denoted as RMC here after) is a primary source material for architectural and public work projects. Projects ranging in size from a single house to a multi-storied building all need RMC for their construction. RMC consists of coarse aggregates, fine aggregates, cement and water, with specified admixtures. Due to the properties of concrete, there is little gap for variability in terms of delivery and placement time after water has been added to fresh concrete. With the high amount of development in urban areas in recent years and to meet the demands of different types of construction, many factories have invested in this part of industry, subsequently increasing the market competitiveness and the operating difficulties of the RMC business in India, which makes their profits vulnerable.

RMC is produced according to customer demand at each construction site; it cannot be prepared and stored in advance. In other words, RMC is a perishable and un-storable material. This means that if the RMC truck delivery time exceeds the concrete initial setting time (the time at which cold joint occur in concrete cold), the concrete becomes waste and must be discarded. To conform to quality requirements, the RMC must be placed within this specified time. Furthermore, the concrete delivery trucks also have a storage capacity constraint which limits the scope of their service. These parameters must be kept in focused when trucks are dispatching. The efficiency of the RMC production system is governed by the plant operator's equipment, the construction sites placement method and individual schedules, as well as the mutual co-ordination of those schedules. Effective scheduling in production of concrete and efficient dispatching are significant issues for both the carrier's production facility and construction site operator. Generally, the plant's batch capacity is larger than its truck delivery capacity. The batch production time is on the order of a few minutes, while the cycle time for a truck, which includes the loading time and the transport time, may be on the order of 30 minutes up to an hour or even more time. Due to significant variability in such constraints, an RMC plant may sometimes be left idle waiting for the trucks to return, while at other time, trucks may have to queue up at the plant or the construction site. This sort of inefficiency often happens in the real world.

Addition, at many construction sites, the normal working time hours may not be sufficient for RMC supply, which also lead to work overtime, resulting in extra costs. The incorporation of different overtime periods into the RMC supply decision (for different construction sites) makes the scheduling problem more complicated when only normal working hours are considered. From the operational viewpoint, the management of the RMC supply involves a set of complex and interdependent combinational problems (e.g., acquisition of raw materials, scheduling of production facilities, routing of transport vehicles, etc.). Even when considered independently, each of the aforementioned logistical problems suffers from a prohibitive combinatorial complexity. Unfortunately, most Taiwan carriers still handling RMC production scheduling and dispatching manually based on staff experience. This method is effective and often results in inferior solutions. To design an effective operation schedule for RMC production and dispatching the carrier must address

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both timeliness and flexibility, often considering the possibility of working overtime to satisfy the construction sites operating constraints. However, systematic optimization approaches to solving such an integrated problems have rarely been developed, owing to the many complex factors and constraints involved.

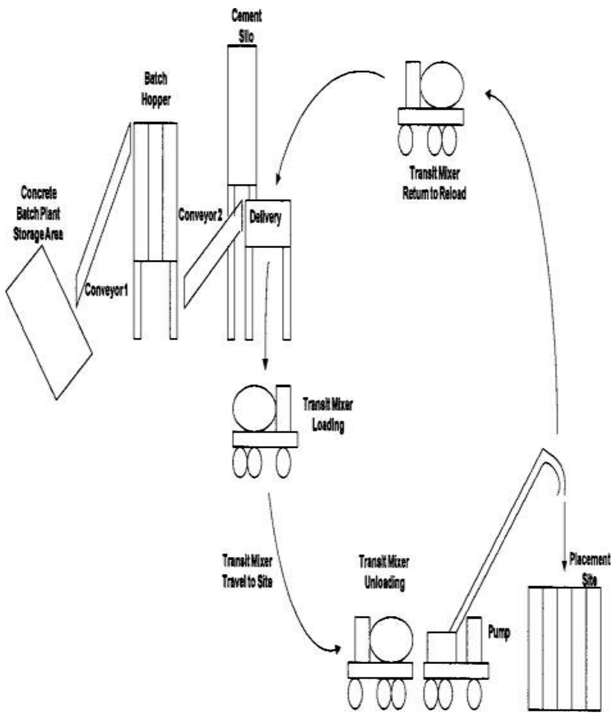

Fig.1 Flow diagram for concrete batch plant and transit mixer cycles

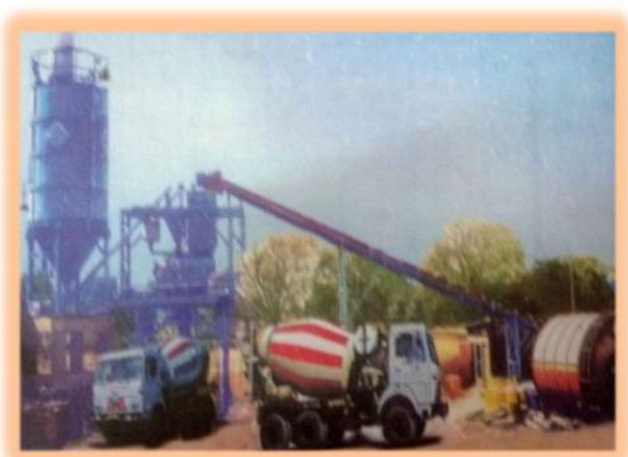

Fig.2 Modern Ready Mixed Concrete Plant

Ready Mixed Concrete (Rmc) – Major Advantages

The major advantages of RMC are recognized:

- Uniform and assured quality of concrete can be achieved.
- Durability of RMC.
- Faster construction speed.
- Storage needs at Construction sites is eliminated.
- The addition of admixtures is easier.
- Documentation of the mix design can be maintained.
- Reduction in Wastage of raw Materials.
- RMC is eco-friendly.
- Elimination of Procurement / Hiring of plant and machinery.
- Labor associated with production of concrete is eliminated.
- Noise and dust pollution at site is reduced.
- Organization at the site is more streamlined.
- Lower labor and supervisory cost.
- Availability of concrete of any grade.

II. OBJECTIVES

The objective of this research is to optimize the operation of aconcrete batch plant. To achieve this goal, several steps must be performed:

(1) Study the concrete batch plant operation to determine the critical resources;

(2) Design the problem statement and its conditions etc

III. LITERATURE REVIEW

1. Ashish H. Makwana and Prof. Jayeshkumar Pitroda (2013) **"An** Approach for Ready Mixed Concrete Selection for Construction Companies through Analytic Hierarchy Process " states thatThe objective of Ready Mixed Concrete (RMC) selection is to identify ready Mixed Concrete with the highest potential for meeting a customer's needs consistently. Ready Mixed Concrete was first patented in Germany in 1903, but a means of transporting was not sufficiently developed by then to enable the concept to be utilized commercially. The first commercial delivery of Ready Mixed Concrete was made in Baltimore, USA in 1913 and first revolving-drum-type transit mixer, of a much smaller capacity than those available today, was born in 1926. In 1920s and 1930s, Ready Mixed

Concrete was introduced in some European countries. Ready Mixed Concrete plants arrived in India in the early 1950s, but their use was restricted to only major construction projects such as dams. Later Ready Mixed Concrete was also used for other projects such as construction of long-span bridges, industrial complexes, etc. There were, however, captive plants which formed an integral part of the construction project. It was during 1970s when the Indian construction industry spread its tentacles overseas, particularly in the Gulf region, that an awareness of Ready Mixed Concrete was created among Indian engineers, contractors and builders. Indian contractors in their works abroad started using Ready Mixed Concrete plants of 15 to 60m3/h and some of these plant were brought to India in 1980s. Currently there are approx. 30 Ready Mixed Concrete Plants operating in different parts of Gujarat. The Ready Mixed Concrete business in India is in its infancy. For example, 70% of Cement produced in a developed country like Japan. Here in India ,Ready Mixed Concrete business uses around 2% of total cement production. Ready Mixed Concrete (RMC) is a

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specialized material in which cement, aggregate, and other ingredients are weight batched at a plant in a central or a truck mixer before delivery to the construction site in a condition ready for placing by the customer. RMC is manufactured at a place away from the construction site, the two locations being linked by a transport operation. Basic requirement for growth of the industry:-

Government bodies, private builders, architects/engineers, contractors and individuals are to be made fully aware about the advantages of using Ready Mixed Concrete.

1) Need Of Innovative Ready Mixed Concrete Selection Model

To understand current practice of Ready Mixed Concrete selection, a survey was carried out on selected Ready Mixed Concrete plants in Central Gujarat region of India. The purpose of the survey was to study the methodology and derive the relation between the various criteria for enhancing the utilization of Ready Mixed Concrete. Figure 2 Given below shows the present approach used by construction companies in selection of best Ready Mixed Concrete. Improper mixing at the site, as there is ineffective control and intangible cost associated with unorganized preparation at site are other drawbacks of RMC. There are always possibilities of manipulation; manual error and mischief as concreting are done at the mercy of gangs, who manipulate the concrete mixes and water cement ratio.

2) Criteria Framework For Ready Mixed Concrete Selection

Ready Mixed Concrete selection depends upon many factors. Literature study and interview with construction professionals were carried out to

prepare the hierarchical framework for Ready Mixed Concrete selection. Criteria which contribute towards Ready Mixed Concrete selection are divided in 10 major groups as: Quality Control, Cost, Delivery, Quantity, Manpower, Safety Measures, Financial Capability, Commercial Capability, Laboratory, and Managerial Capability. These criteria are further subdivided into sub criteria. A final framework for Ready Mixed Concrete selection criteria is given in Figure 3.

3) Analytic Hierarchy Process

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions. Based on mathematics and

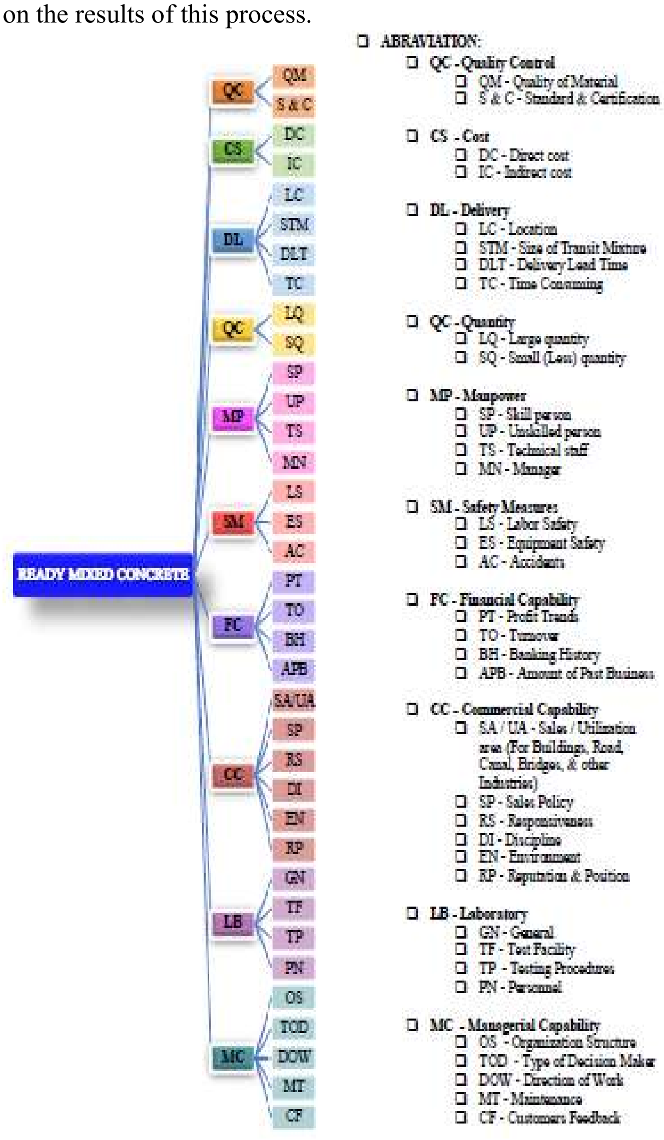
psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education. Rather than prescribing a “correct” decision, the AHP helps decision makers find one that best suits their goals and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

4) Process Of Analytic Hierarchy Process

The procedure for using the AHP can be summarized as:

Model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives.

Establish priorities among the elements of the hierarchy by making a series of judgments based on pair wise comparisons of the elements. For example, when comparing potential real estate purchases, the investors might say they prefer a location over price and price over time. Synthesize these judgments to yield a set of overall priorities for the hierarchy. Check the consistency of the judgments. Come to a final decision based on the results of this process.



5) Proposed Ready Mixed Concrete Selection Process

Ready Mixed Concrete selection is a multi-criteria decision making problem and hence AHP fits to it. It is suggested to use AHP technique for Ready Mixed Concrete selection. So, a survey questionnaire can be prepared based on AHP technique. It will require the experts to compare

various criteria and sub-criteria on 1 to 9 scales. While doing this comparison they have to use their past knowledge and information of criteria as well as available Ready Mixed Concrete Plants.

1. Abdulrahman et al (1999) **-** Introducing And Managing Quality Scheme For RMC Industry In Saudi Arabia.

6) Background On Rmc Industry In Saudi Arabia

In the Kingdom of Saudi Arabia, concrete is the dominant construction material for all types of buildings and other structures. Cement consumption at the present time exceeds 16 million tons per year (''Cement'' 1994). This makes per capita cement consumption in the Kingdom one of the highest in the world. Ready-mixed concrete was first introduced into Saudi Arabia during the construction boom of the mid-1970s. Since then, there has been phenomenal growth in the use of RMC. Nowadays, most RMC is used for most concrete construction in major cities and towns. Currently, RMC use in the Kingdom is, conservatively, estimated to be 20 million m3 per year, which translates into a per capita consumption of 1.25 m3 . In comparison, the highest per capita consumption of RMC in the world is Switzerland, Japan and Italy, with 1.57, 1.50, and 1.23 m3 , respectively (Takeyama 1996). In Riyadh (the capital of, and largest city in, Saudi Arabia), the first RMC plant started production in 1974, and was followed by several other plants. The growth in the number of RMC companies in Riyadh during the period 1975–1995 is shown in Fig. 1. The number of RMC companies increased from 1 in 1975 to 5 in 1980 and then jumped to 14 companies in 1985 and 19 in 1990. In 1995, there were 30 companies supplying RMC to customers in Riyadh. Ready-mixed-concrete companies in Riyadh have a relatively large production capacity. The average weekly production varies from 2,000 m3 to 7,000 m3 . It is estimated that about 70% of the RMC production is used by the housing sector.

Despite the tremendous growth in the use of RMC, the quality of concrete construction in Saudi Arabia is still generally substandard. In recent studies, many RMC plants were found to be producing substandard concrete (Al-Abidien 1992; Arafah et al. 1995). This appears to be the result of widespread disregard for the basics of good quality as well as possible cheating by some RMC producers. The latter is further highlighted by the public complaints in the local press regarding the quality of RMC.

A survey of RMC factories in the early 1990s (Al-Negheimish 1993) depicted a rather gloomy picture of conditions in most RMC plants in Riyadh. The results showed that some plants lacked an operational quality control (QC) laboratory, which is a basic requirement to ensure product quality. Furthermore, about 50% of all factories acknowledged (not performing any control) over concrete temperatures in the long, hot summer months. The method of specifying concrete was also problematic. It varied from plant to plant and, for the same plant, from customer to customer, since there is no local standard to cover this important issue. It was found that 52% of all concrete produced in Riyadh was specified by cement content alone, 36% was ordered on the basis of both cement content and minimum strength, less than 4% was based upon strength, and the remaining 8% was based upon mix proportions specified by the client. The high percentage of concrete specified based on cement content alone is worrisome since no practical field test is available to assure compliance with a specification. Furthermore, ignoring concrete strength encourages bad field practices, such as the addition of extra water at the jobsite, etc. The attitude of most plants toward quality is still less than satisfactory. The main reasons for this attitude include outright cheating; lack of care; lack of technical knowledge; lack of standard operating procedures; and the lack of motives, as there are added costs without clear and immediate benefits or returns to the RMC plant. To rectify the situation and improve the quality of RMC production, a credible external quality scheme for the RMC industry in the Kingdom is required (Al-Abidien 1992; AlNegheimish 1993; Williams 1994; Al-Medallah 1996). The Municipality of Riyadh has recently taken the lead in this regard by embarking on a comprehensive quality scheme to make sure that local RMC plants in Riyadh produce and maintain good quality concrete. The scheme was started in early 1995 and covers all 30 operating factories. The main focus of the Municipality's scheme is an in-house quality control program conducted by the RMC plants themselves, and supplemented by external checking, auditing, and testing.

7) Quality Scheme Outline

Difficulties and Challenges The introduction of a quality scheme in a developing country is sure to face many problems. In Saudi Arabia, the quality scheme for the RMC industry was developed with the following major difficulties, challenges, and constraints in mind:

- There were no local standard specifications covering RMC; therefore, interim regulations and requirements had to be adopted.
- The so-called quality infrastructure, such as professional societies and accreditation boards, are still nonexistent or in the early stages of development. Therefore, many activities relating to the implementation of quality schemes cannot be delegated to others as they are in developed countries.
- Most concrete testing laboratories in Riyadh are not accredited. Inspection visits to some of these laboratories showed there were major problems with their methods, especially in regard to concrete curing and testing.
- Unlike the situation in most developed countries, most RMC producers in Saudi Arabia are small companies operating single plants, which means limited staff with expertise in concrete technology and quality systems.
- The majority of RMC customers in Riyadh are small owner-builders who generally lack a basic knowledge about concrete and its properties**.**

8) Scheme Strategy

Considering the fact that implementing a quality scheme in the Kingdom is a new experience, and bearing in mind the aforementioned difficulties and challenges, the management of the scheme adopted the following strategy during the planning stage:

1. The quality scheme would be mandatory and cover all RMC plants operating in Riyadh. In developed countries, production of quality RMC is assured through either voluntary or mandatory quality schemes; however, a mandatory scheme is required in developing countries as the conduct of both producers and users has not reached the level of maturity and professionalism of their counterparts in most industrialized countries.

2. The scheme would focus on random independent testing of concrete and concrete-making materials. These surveillance activities would be assigned to an independent testing laboratory operating under the supervision and direction of the scheme management.

3. Random sampling and testing of concrete would be restricted to the plant. It would not be implemented at the jobsite despite uncertainties regarding the technical validity of such practice. This was done to avoid legal issues and disputes, which may undermine the scheme before it takes root.

4. The requirements of the scheme would be introduced gradually to keep its impact on the producers and on RMC prices as low as possible. At the start, emphasis would be placed on first-hand external testing and evaluation. Ultimately, a quality system similar to QSRMC (1997), following the format and approach of ISO 9000's series on quality systems, would be the target.

5. Both ASTM and BS standards would be used. For strength testing, cubes in accordance with BS 1881 would be used because they are simpler to test. 6. The scheme would be self-financed through annual fees paid by RMC producers.

Scheme Objectives

The main objective of the scheme is to ensure that quality concrete is produced by RMC factories in Riyadh. A survey of RMC plants in Riyadh, conducted at the beginning of the scheme implementation, showed no major improvements over the conditions described earlier (Al-Abidien 1992; Al Negheimish 1993). Therefore, efforts were directed toward achieving the following interim objectives in order to assure quality:

1. Upgrading of plant equipment and facilities.
2. Documenting and exposing cases of intentional cheating to help eliminate such practice from the RMC industry.
3. Evaluating the competence and effectiveness of the QC staff in each plant.
4. Pressing plants to activate and improve in-house quality control practices and programs.
5. Categorizing plants into classes based on plant facilities, capabilities, and quality record.
6. Setting up and implementing an annual ''plant of the year'' award program to reward outstanding performance.
7. Developing a database about the RMC industry in Riyadh to help develop local specifications for RMC.
8. Educating RMC producers and the public about the quality of RMC and important factors affecting this quality.

Scheme Elements

The scheme consists of the following five interrelated tasks, which are key to its success:

1. Inspection and surveillance programs
2. Scheme's internal quality assurance (QA) program
3. Administrative and follow-up activities
4. Technical support and development
5. Public awareness programs

9) Inspection And Surveillance Programs

Consist of plant inspection and evaluation, validation and approval of mix designs, and surveillance activities. A preliminary plant inspection and evaluation is performed at the beginning of scheme implementation, and an extensive inspection and reevaluation are conducted annually thereafter. The evaluation is done against checklists similar to those prepared by the NRMCA (1984) and deal with the following aspects of RMC plant operations:

- Site layout and environment
- Material storage and handling
- Batching and mixing equipment
- Truck mixers and agitators
- Hot-weather precautions
- QC laboratory and personnel

The mixes are validated and approved annually to verify the properties and compositions of the standard mixes marketed by RMC producers to the general public. The surveillance activities involve extensive random testing of concrete and concrete-constituent materials. The program for materials sampling and testing concentrates on the aggregate and water Because most of the cement used by RMC comes from a single source, limited testing was done on the cement to verify its manufacturer's data. Later, the certificate of the manufacturer was judged to be sufficient. The RMC producers mainly use water-reducing and retarding admixtures (ASTM C494, Type D) supplied by a few producers, and the technical data supplied by the manufacturer were considered to be sufficient. Aggregates are sampled from the material stockpiles at the plant, while the concrete samples are randomly sampled from the delivery trucks in the vicinity of the plant without prior notice.

For concrete, the random sampling and testing are done one to three times a month for each plant depending on its size and production capacity. This extensive sampling and testing was necessary because no reliable data existed about the quality of concrete produced by RMC plants. Furthermore, many of the RMC plants in Riyadh did not have any in-house QC activities or records; for those who had, the reliability of such data was highly suspect. This program will continue with the same intensity until the reliability and effectiveness of the internal QC practice at each plant are well-established and verified. On each sample of concrete, the following tests are performed: (a) slump; (b) concrete temperature; (c) unit weight and yield; (d) compressive strength based upon six cubes (15031503150 mm) to be tested at 7 and 28 days; and (e) cement content of fresh concrete for some samples.

IV. CONCLUSION

❖ RMC operations are highly mechanized and controlled through equipment and hence reduce the probability of errors in operations.

❖ It is also environmentally friendly and brings down pollution due to dust at construction can also be accelerate with the use of the RMC.

❖ Ready mix concrete has gained acceptance in Indian industry due to some advantages including quality control and overall economy.

❖ The current study has developed a framework which contributes for Ready Mixed Concrete selection.

❖ Selection of Ready Mixed Concrete is a multi-criteria decision making problem, Analytic Hierarchy Process is preferred for obtaining the solution. AHP based Ready Mixed Concrete selection approach is preferred in this study.

❖ Such approach will be comprehensive and will include the relative importance of criteria in the decision making. Civil Engineers are encouraged to use such innovative and simple tool like AHP to support their decisions which will finally support for the project success achievement.

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