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Application of Operations Research in Construction of Drainage System

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➢ ***Research Objectives***

- **To understand the problem faced by the financial capital of the country with regards to storm water management**
- **To understand the need of renewal of storm water drainage system in Mumbai**
- **To understand the prior application of OR techniques in the construction (civil engg) industry**
- **To discuss a solution for the same**

➢ ***Research Methodology***

The research methodology used with regards to this paper is qualitatively analysing the secondary data collected from various published research papers. With the help of these national and international papers, usage of OR techniques in the construction industry are explained and an in-depth analysis of the application of OR techniques in the renewal of drainage system is discussed.

Abstract:- New and better solutions to management problems in the construction industry are essential if demands of contemporary society for habitat are to be met. Operations Research is defined and presented as uniquely successful in providing such solutions. The ongoing drainage problem in the city of Mumbai is defined and reasoned. A probable solution, reconstruction of civil utilities is discussed with the help of the use of OR. Eight basic forms of O.R. are defined, examples are given from Construction of their use. Covering the entire spectrum of engineering applications of operations research in a single article is nearly impossible.

I. INTRODUCTION

Every organization in the construction industry, during Its lifetime, takes up various projects to be worked upon. The traditional approaches of carrying out the processes are generally focused on the assumption that there exists a single objective that Is to be achieved and the problems are well formulated, making It fairly easy to be looked upon on paper. Yet the real-world modelling takes a lot more into consideration than a single point of view hence leading to a more complex model. Hence there is a need for new ways and techniques to efficiently manage these large-scale projects, due to the contribution the construction Industry makes to the future development of the nation, paving way for the application of operations research In the construction Industry and civil engineering projects per se. (Phatak, 2007)

II. DRAINAGE PROBLEM IN MUMBAI

Mumbai's monsoon extends from June to September, 4 months receiving average rainfall of 2000mm, 70% of which falls in July and August. It's storm water drainage (SWD) system has a core which is 70 years old, built on the basis of then weather conditions and population, having the capacity of holding only 25 mm per hour of rain intensity on a low tide. Rain intensity of more than 25mm per hour would result in a heavy tide leading to water logging at various points in the city. (Forest Clearance, n.d.)

Mumbai is bordered by the Arabian Sea on the West, intercepted by Thane, Mahim and Mahul creeks and Mithi, Dahisa, Poisar and Oshiwara rivers and has a complex Nallah system.

It's SWD system comprises of about 2000km of roadside suburban surface and underground drains, nallahs and 186 outfalls out of which 107 are major outfalls discharging the surface runoff directly into the Arabian Sea. 14 of the outfalls drain into the Mithi River.

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Since Arabian Sea plays a prime role in the discharging of sewage and storm water, tidal variations in the sea current have major impact on the SWD. Occurrences of flooding and water logging during high tides and heavy rains becomes inevitable and the recession of water at the time of low tides is another problem. (Phatak, 2007)

Floods are the common and frequent cause of disruption in the city as witnessed in the years 1985 and 2005 which received massive amounts of rainfall in contrast to the meagre capacity of city's SWD system which lead to lethal flooding along with increase in the rail and road traffic nuisance and industrial losses. Lesser extreme forms of such events continue to occur at least 2-3 times a year, till date. (Forest Clearance, n.d.)

Prime contributors to the floods other than variations in the tides and flat gradients are the inappropriate levels of manmade outfalls along with poorly structured, dilapidated and encroached drains, excessive siltation of drains due to sewage and garbage inflows and increase in the runoff coefficient. (Forest Clearance, n.d.)

Mumbai has experienced one of the worst floods ever due to unprecedented rains on 25 July 2005. There had been a huge loss of life and the overall economy as well as a huge loss of properties. CWPRS and MRPDA, these were appointed by the Maharashtra government to look towards Mithi river from Mahim to Vihar lake suggesting deepening of the path of the river with the immediate effect- earlier in 2006. MCGM approved 20 cr. to undergo with the works of the destructions for the event. Similarly, WAPCOS has been three rivers to study which are Oshiwara, Poisar and Dahisar on their lines. (Forest Clearance, n.d.)

The severity of floods in Mumbai, in July 2005, was due to three major reasons – firstly the record rainfall during that time, the simultaneous occurrence of high tide and most importantly due to the lack of a proper drainage system. Most of the drains from the Mithi River were blocked with plastic waste and sewage, stopping the flood waters from being discharged into the sea. As a matter of fact, most of the coastal cities of the world face a similar problem.

The Central Water and Power Research Station studied the drainage situation and gave recommendations for the flood mitigation. With the help of the 1-D mathematical model and Desk Studies conducted by the institute, the discharge capacities can be doubled, making

the drainage capacity sufficient to discharge a 100 year rainfall! Another recommendation is to alter the depth of the upstream stretches of Mithi River in order to make the gradient flat or moderate. This will result in an increase in water retaining capacity of the upper reaches, hence preventing flooding downstream. (Forest Clearance, n.d.)

Over the last two decades floods have become a major risk for the low lying slums in Mumbai. Hence their mitigation reduces the risk of flooding in the entire megacity. The recommendations of CWPRS are based on the current demographic data and topography. The rapidly growing population is a major threat as the present infrastructure won't be able to support it for long. As a result more and more topography is being drastically altered, area being reclaimed and hills and forests being destroyed. This may lead to an increase in flood prone areas and hence the overall risk in the city. (Forest Clearance, n.d.)

Hydrological disasters floods may lead to catastrophic conditions with consequences affecting public health and may even provide damage to personal property. These disasters generally results in loss of life, destruction of public health infrastructure with substantial economic losses. After the flood incidences increasing cases of drowning and injuries are expected. IASC 2007 in a literature has documented the impact of emergency situations during flood incidences on mental health. These even lead to an increase in the risk of water and vector borne infectious disease. The other repercussions these floods leads to is disruption of health systems when they are needed the most and damage to essential infrastructure such as food and water supply. The IPCC has published a report showcasing the expected number of people impacted due these disastrous floods in 2030, the number of people being affected tends to rise when compared to people being affected to these disastrous floods in 1970s. According to their calculation number of people being affected by these disastrous floods will rise all over the world. The expected rise in the number of people being affected by these in 2030 is 0.22 million people in Europe and 47.85 million people in Asia when compared to 1970s. (Forest Clearance, n.d.)

III. PLANS RELATED TO STORM WATER MANAGEMENT AND DRAINAGE

➢ *Brimstowad Proposal*

The severe flooding which happened in 1985,The MCGM planned a master idea for storm water drainage system in greater Mumbai, they diagnose the water and ensured the efficient storm water drainage system to address the issue- the Brihan mumbai storm water drain(BRIMSTOWAD) project. They carried out 15% of the recommendations and the reasons for the non-implementation of the recommendations are:

A) Financial resources were less than required hence a problem of monetary allocation to be worked upon;

B) The utilities were shifting day by day;

C) CRZ conducts constructions of pumping stations at outfall locations;

D) Rehabilitation and Relocation costs, therefore need to aim at cost minimisation for the project.

Keeping in mind the above scenario, we felt there should be heavy investment in the improvement and rebuilding of the drainage systems of the city. We tried to analyse the applications of OR, for the same. Which leads us to working on the use and potential of OR in the construction sector since drainage systems come under the construction of public utilities. (Phatak, 2007)

IV. THE EIGHT BASIC PROBLEMS THAT CAN BE SOLVED BY OPERATIONAL RESEARCH

➢ *Problems Related To Inventory*

To Minimize the sum of the relevant costs of the selected quantity and the Frequency of acquisitions, these problems generally arise. "resource" is something which is used to obtain a new thing (machines, men, money, material and time) and "inventory" is something which is a resource but is not being used. There is a distinguisher of two different types of coast which is related with idle resources which are: A cost which gets on decreasing while inventory rises(the labour cost, cost by lost sales, etc) and the other is cost gets on increasing as inventory also increases(obsolescence, spoilage cost, etc). The construction industry can make use of the inventory analysis for designing, programming, maintenance and construction levels is evident and manifold. (Dalice, 1971)

➢ *Allocation Problems*

These type of problems can arise due to three conditions. These conditions are as follows:-

- *Type 1:*

There are many jobs to be done and there is enough resources available for doing all of them. Some of these jobs can be done in more than one way by using different accounts and combination of resources. Some of this ways of doing the jobs can be better than other ways. The problem is to allocated resources to the jobs in such a way that the overall efficiency is maximised. When each job requires one resource and there are equal number of jobs and resources, it is called Assignment Problems. Accordingly if each job requires more than one resources and when one resource can be used for more than one job, it is called Distribution Problem. (Dalice, 1971)

- *Type 2:*

In this type, the basic condition is that there are more jobs to be done than the number of resources available. Therefore to optimise, selection of jobs must be made as well as determination of how these are done is to be taken care of. (Dalice, 1971)

- *Type 3:*

In this type, there is a constraint on the number of resources. Hence while assigning, it must be determined what resources are to be added and what resources to be disposed of. Also keeping in mind where these added resourced need to be assigned. (Dalice, 1971)

➢ *Queuing Problems*

These problems arise when service must be provided to meet an irregular demand. The costs associated with them are dependent on the length of the waiting line and the time lost in waiting. There are also capital and labour costs, associated with increasing the capacity of the servicing unit. Due to random arrivals, there are times when there are waiting lines and other times when there is idle servicing capacity. As soon as the mean arrival rate tends to become equal to the capacity, the length of the waiting line will tend to infinity, provided that the capacity is a little greater than the mean arrival rate. The optimal solution for such a type of problem will provide a processing capacity which is just in excess if the mean arrival rate to minimise the total processing capacity cost as well as the waiting cost. (Dalice, 1971)

➢ *Routing Problems*

These problems arise when the objective is to route movement between points with a minimum of travel time and cost. In case of construction l, the pipelines can be laid through routing, along several routes. In such a situation the problem faced by the engineer is to find such a route through which all the connections are made, given the location of the outfalls. To minimise the cost component, it is essential to use the shortest route for laying down the pipes, which in turn reduces the length of the pipe used. (Dalice, 1971)

➢ *Replacement Problems*

These problems involve the decisions of equipment renewal or replacement in such a manner that the operating costs and the investment costs are as low as possible. The basic idea here is of depreciation, according to which every machinery or equipment used anywhere depreciates with time. This type of problem solving methodology is useful in measuring or predicting the quality of obsolescence in construction. This will lead to maximum saving with the help of routine service procedures. One of the examples is of routine check-up of dilapidated drains and subsequent servicing. (Dalice, 1971)

➢ *Competitive Problems*

Competitive problems involve more than one decisionmaker, and presume that a decision made by one decisionmaker is changed, altered or affected by the decisions made by one or more of the other decision-makers. The relationship between the interacting decision-makers may be either cooperative or competitive. The problem is to positively increase the effectiveness of the competitive situation. There is little current application of this problem solving methodology in Construction. (Dalice, 1971)

➢ *Search Problems*

These problems apply in those cases in which an appropriate choice must be made among several alternatives. The procedure is basically the following: the quantity of resources (time, money, etc.) must be fixed; the coverage (sample size or quantitative aspect of alternative) must be selected and the type (sample design) must be taken into account. It must be borne in mind at the same' time that if more resources are employed, the cost of the search is greater, but the expected margin of error (cost of error) is decreased. (Dalice, 1971)

➢ *Sequencing Problems*

These problems arise when it is necessary to lay out activities of a project in the time order in which they must be performed. From a managerial viewpoint, these problems can be called Scheduling problems according to the basic managerial functions of Planning, Scheduling, and Control. Sequencing is concerned with processes which are unique and which are performed only once (Research and Development programs, Construction projects). Some steps of the process must precede others; some may be done simultaneously.

1. DESCRIPTION
2. THE CASE STUDY
3. THE NETWORK
4. THE CRITICAL PATH
   -AN ALGORITHMIC METHOD
   -A COMPUTER PROGRAM
   -A LINEAR PROGRAMMING FORMULATION

5.PERT MODEL
6.CPM MODEL
7.NETWORK COST SYSTEM
8.USERS OPINIONS
9.FAST TRACK

These problems are known as Scheduling problems and may arise when it is important to lay out activities in time and order. Sequencing focuses only on processes that are unique and are required to be performed only once. Some steps in the processes needs to precede others and some of these steps will be done simultaneously. Sequencing problems may establish starting and due dates.

In the construction industry, simply minimizing the initial cost with a drop in the quality results in the higher maintenance cost in the future. It also results in the low satisfaction of the user of the utility. The major problem is measuring the relation between the cost spending and the outcome of building as it varies with each construction type, vendor etc. This is a major complication as once the construction is completed it becomes more difficult and costly to measure the tenant levels. Operations research is the scientific study of the operations which will help in better decision making and managing things effectively. Disasters are defined as occurrences who's concerns exceed the ability of the civil protection and public health systems to provide essential reactions in a timely manner. Operations research is a scientific area where methods coming predominantly from mathematics, computer science and economics are used in the process of decision making. The tools established by are OR are employed to judge the significances of alternative decisions of long term or short-term nature such as strategic planning or functional decisions. Hence, OR can be seen as the science of resource allocation in the most efficient way. In connotation with disaster preparedness and replies and the impact on public health OR can contribute in the assessment of operational strategies and actions associated with the large-scale natural calamities. OR can provide assistance on the optimal choice of these strategies and actions in consideration. (Dalice, 1971)

- *The Basic form of or*

All the OR models are converted into an equation from which the system's overall performance (P) is measured by equating it to certain relationships (F) that can be aspects that are controlled(Ci) or cannot be controlled(Uj).

Thus the basic form of OR problem is given by: P>>F(Ci,Uj) where P is performance and depends upon important controlled and uncontrolled aspects of the system. Therefore in order to obtain the solution one seeks to find the value for controllable variable (Gi) that results in maximizing the 'Performance' of the system.

Basic form of OR equation: P>>f(Ci,Uj)

Where P: system's overall performance
Ci: set of controlled aspects of the system
Uj: set of uncontrolled aspects of the system

Like all other industries the construction field has its own set of controlled(Ci) and uncontrolled variables(Uj).

Ci: There will not be much emphasis done on defining the controlled variables as they tend to be common in all 13 industries; raw material, manpower, equipment, time, price, product performance etc.

Uj: the construction sector has some specific characteristics which causes many uncontrolled variables.
The specific characteristics are:
1. Weather hazards at the construction site.
2. Hazards of surface condition for foundations even well the preconstruction test are well executed.
3. Hazards of time i.e. beginning of the construction is never reliable as it accounts for administrative formalities (Construction permit, site condemnation, dedication etc.)
4. Traditional building is a unique building which is hard to define with accuracy. (Phatak, 2007)

V. LITERATIRE REVIEW

Today the world demands that its habitat is built faster, cheaper and better. For meeting such demands new or more efficient production processes are necessary. To be a new or more efficient process there must be:
1. New design
2. New technological ideas
3. New organizational ideas

There have never been shortages in good ideas in design and technological levels in the construction sector but it has always been hard to implement these ideas successfully due to lack of organization. There have been many ideas for construction systems but only a few have been realized. OR techniques have helped provide hopes to successfully implement these ideas by finding the optimal solution with the correct path.

OR techniques are shown to be useful not only in solving management problems but also on solving many problems that arise at different levels of the construction process. The OR viewpoint applies to task and interrelationships of the participants in the construction process. But the problem has been that these tasks are difficult to define due to the difference between professional title and function to be performed which seems to grow wider and wider.

Today in the construction field, the decision-maker has to make economical optimal solutions. As the problems have been growing in number, kind and complexity there have been more constraints and also the resources are scared. The decision-maker should not only find the optimal solution but must also provide a path to reach these findings. The decision-maker must involve himself in solving the problem and statement of the problem.

VI. CONCLUSION

The first goal of this study was to analyse the management tools which can be effective in smoothing complex passages from theory towards practice exercise. But these tasks were difficult to define because there was a gap between function to be performed and decision maker which has been growing wider and wider:

- Code of law towards technology solutions and imposing design
- The Architect were able to make a few of design decisions.

The construction sector, the "decision maker" will have to provide functionally, formally, and economically optimal solutions. Since problems were growing in kind, and number, sand increase in more constraints, and resources are not unlimited, the maker or the decision maker must not only get optimal solutions but also try to provide services to get reach these findings; They must get involved in solving of the problem with the statement of the problem. Management is a process of organizing disorganized scare resources with a simple objective of gaining the most out of the them. Unfortunately, In construction field it is impossible to create a business model that can predict all the realities adequately. The construction model is pretty complex and it does not allow use of mathematical to create a feasible model. All we can do is to apply techniques as we have noticed in case studies. These techniques not only must consist of traditional methods but also use other methods that result in providing feasible solution and reach optimality. OR is the new mainstream in the field of construction, OR techniques result in a break with the old traditional techniques of construction in reaching optimality (better quality and low cost and low time) by applying scientific method and forces to search for new methods. OR has already been approved by other sectors before, these techniques have resulted in providing great experience to decision makers in and off construction field.

LIMITATIONS

1) The theory of management science needs to become more practically applicable than academic for the practitioners to use it thoroughly.
2) A mix of minimizing costs and maximising the user satisfaction along with the proper will of the decision maker should be adopted.
3) The effect of costs on the large-scale construction projects are hard to measure yet are very crucial to the proper establishment and working of the models hence more accurate solutions need to be found.
4) A widely known challenge for OR is to reflect upon the conflicting interests of different stakeholders in the organisational hierarchy at the construction site.
5) The technique of Integer programming and its revised models can be utilised in managing HR allocation. (Dalice, 1971)

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