Arresting Slippage in Water Resources and Other Infrastructural Projects

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1: INTRODUCTION

1.0 Projects do suffer delays or slippages initially and/or in various intermediate stages during implementation. Many of these delays causing project slippage can be effectively arrested with proper planning and by deploying continuous and sustained efforts. Slippages left unmanaged get compounded and eventually go out of control. It is therefore, imperative that all these slippages have to be closely monitored and controlled throughout the project life cycle.

Over the last few decades engineers and planners in India have been using activity network techniques like PERT and CPM with the application of modern Project Management (PM) Softwares like Microsoft (MS) Project, Primavera P3 etc for Planning, Scheduling, Monitoring and Controlling the projects. It is a reality that in spite of application of such state-of-the-art techniques projects do slip and at times go beyond control.

The author has done considerable work in India and abroad trying to find workable solution to this burning issue on real-life projects.

According to the Concise Oxford Dictionary the meaning of Project and Management are as follows:

a. Project– a plan, a scheme, a course of action.

b. Manage– to handle, to conduct, to regulate, to organise, to take charge of, to take control of.

c. Management - Persons engaged in the act of managing, administration of business concerns and Public Undertakings.

Based on the above definitions, management of a project should literally mean taking charge of, organising and keeping a control on the project.

The term Project is a very broad and general one and covers a wide spectrum of activities from a low cost rural housing project to a multi billion dollar missile or space project. This White Paper, however, relates specifically to Water Resources and other Infrastructure Projects of various magnitudes and complexities.

In a broader sense, the management of a project is the knowledge, tools and techniques to lead, plan, organise and control the projects. So the basic processes are: -

- Leading – motivating people to perform satisfactorily.
- Planning – determining in advance what will be achieved by implementing the project.
- Organising – arranging resources in a manner such that the achievement of project goals are expedited.
- Controlling – determining how effectively the project is progressing in accordance with the approved plans and taking corrective actions, wherever necessary

1.1 TYPES OF WATER RESOURCES AND RELATED INFRASTRUCTURE PROJECTS

- Different types of Water Resources and related Infrastructure Projects may be categorised primarily into four groups. These are:-

(A) Surface water consisting of Sea Water and other sources of water-

i. Dam and Hydroelectric projects.

ii. Barrage, Canal, Headworks.

iii. Irrigation and Flood Control.

iv. Water Intake, Water Treatment, and Distribution Network.

v. Dredging, Embankment Protection and River Training.

vi. Preservation and Improvement of Wetland.

vii. Sea Water Desalination Projects.

(B) Groundwater:-

i. Groundwater Exploration and Conservation.

ii. Rain Water Harvesting and Recharging of Groundwater.

iii. Prevention of Groundwater Pollution.

iv. Mitigation of Arsenic and Saline Water Intrusion in Groundwater.

v. Prevention of Groundwater Lowering and minimising possibility of large scale Land Subsidence.

(C) Sewage and Effluent Treatment: -

i. Sewage and Effluent Treatment Plant and its disposal and/or recycling.

(D) Others:-

i. Protection of overall Environment.

ii. Storm Water Drainage system including its disposal and/or recycling.

1.2 CAUSES OF SLIPPAGE IN IMPLEMENTATION:-

The causes for slippage in project implementation are many and in most cases multiple causes occur simultaneously. Some of the delaying factors are internal, that is, somewhat within the control of the project authorities. Some of the internal factors causing slippage are:

Access to Site; Clearance from Local Authority; Project Funding; Contractors' Mobilisation; Availability of Drawings; Availability of Materials, Equipment and Labour; Identifying Problem Areas; Decision and Implementation of Corrective Action, etc.

Some of the external factors causing slippage are:

Heavy Rain, Storm, Flood; Failure of Water and Power Supply; Government Act; Outbreak of Epidemic; Labour Unrest, Strike, etc. Needless to say, these are beyond the control of the project authorities.

1.3 POSSIBLE REMEDIAL MEASURES:

In case of a slippage in the overall project or in some intermediate activities it is necessary to apply suitable corrective action or remedial measure to arrest the slippage and bring the project back on schedule. There are many possible remedial measures and it is not possible to apply a standard rule on all situations. The engineer-in-charge needs to apply his judgment and adopt the most appropriate cost effective solution to get the best result. To bring the project back on schedule the activity network has to compressed. The most common methods adopted are:

- Change the logical sequence of activities by taking up more activities in parallel.
- Curtail the duration of activities by deploying additional efforts. The remedial measures have to be followed up closely to evaluate how the project is responding to the corrective actions applied. In case the response is not encouraging, revised measures have to be adopted to achieve better result. It must be understood that projects always have a tendency to get delayed unless proper control is exercised all through. Project Monitoring and Control is a complex affair with many variables involved and no easy solution is available.

Some of the basic steps in arresting project slippage are as follows.

- Organise an effective and an efficient project team.
- Ensure good top management support.
- Ensure good expertise at managerial level.
- Ensure that the organisation is flexible enough to meet a changed situation.
- Establish a computerised database.
- Adopt activity network-based planning and monitoring with application of appropriate management software.
- Adopt a streamlined system of identifying and recording delays.
- Adopt a regular system of problem analysis and delay analysis.
- Adopt a system of regular review meetings and follow-up the agreed actions.
- Evaluate results of corrective action and revise the action where needed.
- Be consistent in follow-up.
- Take responsibility and do not look for scape goats.

2 : REVIEW OF LITERATURE

A review of literature indicates that considerable research work has been done in the related areas. The most important and relevant contributions have been summarised and incorporated sequentially under the following three categories:

2.1 WATER RESOURCES, ENVIRONMENT AND INFRASTRUCTURE PROJECTS

Okun, D.A. (1991) has expressed the view that in many cities of Asia, Africa and Latin America there have been inadequate supply of safe drinking water and that the situation has not changed over the last 50 years. Limited water resources and the poor facilities used to treat and distribute water in compounded by the absence of proper sewerage. Despite the efforts by UNDP., World Bank and WHO the situation in these cities are worsening. In cities where public water supply is inadequate and developers sink wells, the water table is lowered causing land subsidence and in coastal areas, salt intrusion ultimately fouls the wells. The absence of sewerage is even more serious. The wastewater is discharged with practically no treatment causing the superficial water and the soil to get badly contaminated. Lack of basic sanitation and water supply causes many water-borne diseases particularly among infants. The growth of urban population caused 15% increase in the number of city dwellers not receiving water services and all most 30% increase in the number of those residing in the neighbourhoods without sewer systems. Except desalination of sea water, which is beyond the financial capabilities of all but a few rich countries, there is no new source of fresh water.

During the second half of the 20th century, the world population grew by 150%, but the urban population grew by 300%, so at the end of the century about half of the total population lived in cities. So, cities throughout the world face water shortage. Recycling of wastewater after treatment is a good option and has been adopted in some countries for landscape irrigation, flushing of toilets, etc. This calls for massive capacity building on water and sanitation management. The essential ingredients in capacity building in institutional development. These include:

- Government, administrative, regulatory and operating agencies;
- National and local quasi-government agencies;
- Local public utilities for water supply;
- Private companies that own and operate water utilities;
- River Basin Organisations for implementing effective water resources management.

This has been very successful in England and Wales. Formulation of appropriate water strategy must be done with necessary changes in Laws, selection of suitable personal, deployment of Professional Associates, Private Companies and Consumer Organisations. The situation has to be tackled with a holistic approach.

Basu, T.K. (1998) has expressed the view that the total water available in the world is adequate but about 97% of the available water lies in the salty oceans and another 2% in glaciers and ice caps in the Polar Regions. Less than 1% is available as fresh water in lakes, ponds, rivers, streams and in underground aquifers. Water is on a constant move in an unending cycle. The sun, being the inexhaustible power house, keeps the water cycle moving – from the earth to the clouds and back again in the form of precipitation to complete the cycle. The water vapour stored in cloud form tiny droplets or minute crystals of ice by condensation and when heavy enough they fall back on the earth as precipitation mostly in the form of rain, hail or snow. Attempts have been made to create artificial rain by using silver iodide but the results have been far from satisfactory. Towing of large icebergs from Greenland or Antarctica to Saudi Arabia or Perth, Australia, have been proposed but the economics of such proposals are yet to be ironed out. Of all the water stored in underground aquifers, only one-third is within viable pumping level.

The Special US Commission in their report "The Global 2000 Report to the President – Entering the Twentyfirst Century" assessed the respective replenishment rates in selected countries. Both USA and India range from very arid to very humid regions. India with 485 mm mean annual runoff is much above the world average of 250 mm.

The many uses for which water is drawn from surface and ground sources are:

Domestic use; Industrial use; Crop irrigation and Energy production excluding hydroelectricity generation.

In India 36% of the irrigated land is classified as damaged due to waterlogging and salinisation. The corresponding ratio in the USA is 27%. Some irrigated areas are supplied from underground sources. High rates of withdrawal may cause land subsidence (for instance Calcutta and adjacent areas).

The key issues in efficient use of available fresh water are:

Important environment linkages; Growing imbalance between water availability and demand; Rapid industrialisation with growing problem of water pollution.

The most polluting industries are the fastest growing industries in the Third World. These include pulp and paper, chemical products, petroleum refineries, non-ferrous metals, leather and tannery, textiles, etc. Steel, although a polluting industry, is much lower in the list as a polluter. Due to rapid growth of industry water and energy, usage per capita increases and it tends to shift towards dirtier fuels (example China, India, Thailand). With higher degree of industrialisation the water and energy consumption per capita would decrease with a shift towards cleaner fuel, like natural gas.

India with its very complex problems relating to high population and poverty should be very careful on the point of economic use of water and energy.

Banyard, J.K. and Bostock, J.W.(1998) discussed that the management of corporate asset base was increasingly being recognised as an essential function of water utilities. It was needed to meet the regulatory requirements and also recognised the need to produce long term increment plans and target capital expenditure in the most cost-effective manner. Severn Trent, the leading water authority in the UK had developed an integrated suite of computer programs which enabled its long term capital programmes to be defined at scheme level in order to optimise the delivery of all regulatory outputs.

Utility businesses can be classified broadly under – Asset-Based, Customer-Based and Product-Based. A utility company like Severn Trent Water, UK, needs to address all the three elements. The company needed to renew and renovate this asset base in addition to enhancing its capability to meet ever increasing tighter standards. The principal benefits of developing more sophisticated planning tools is to allow the asset base to be managed at a corporate level in a way which will ensure that future investment delivers maximum benefits for customers and shareholders alike. Hence, Severn Trent chose to embark on an ambitions computer-based model, aimed at calculating investment for its thousands of surface sites at operating level. Those online computer methods are:

Serviceability Assessment, Demand Forecasting, Regulatory Compliance Forecasting, Outline Design and Cost Estimating.

A team of five specialists, based at the company headquarters at Birmingham, UK, was responsible for routine operation and maintenance of the software. Special data collection exercises had to be undertaken once every five years. The model demonstrated the ability to establish and control large capital programmes engineering project level. The methodology appeared to be applicable to any organisation with a large asset base who wished to optimise the control of a major investment programme.

Sengupta, B.K. (2000) gave an overview of the Water Supply scenario in the Calcutta Metropolitan Area. A large amount would be needed to be spent on Distribution System Renewal. The customers have to play an important role in management of the Water Distribution System. Need was felt to use effective tools to develop cost effective renewal programme and an efficient information system management. Need was also felt to use computerised tools to monitor performance, improve efficiency in energy consumption and utilisation of human resources.

The Calcutta Metropolitan Area (CMA) is the second largest urban agglomeration in India with an area of 1380 sq km, a population of over 12 million having 3 municipal corporations, 38 municipalities and a large number of non-municipal urban units. Calcutta City Proper has an area of 187.33 sq km and a population of 4.38 million in addition to a floating population of 2 million. Calcutta was once the capital of India and had the distinction of having the first major schemes for water supply, sewerage and street lighting next only to London. These facilities were meant primarily for the city’s core inhabited by the members of the ruling community in those days. As the city grew by leaps and bounds, additions were made without any rational comprehensive approach. The huge influx of displaced persons after the partition of India in 1947 added to the misery of Calcutta completely disrupting the socio-economic fabric putting severe strain on the already strained civic infrastructure.

Calcutta Urban Development Programme (CUDP) has been taken up for implementation in three phases, viz CUDP I, II, and III including Distribution System Study subdividing Calcutta into few independent districts. The Master Plan norms are found to be too ambitious to be achieved within a given time frame with limited cash flow. Consumer wastage and wastage through leaky mains resulted in wastage of costly treated water. Also, costs of operation and maintenance must be met by revenue earned through user charges.

The Mega City programme was started in the mid-nineties and has been in progress on many fronts. Future programmes:

- Stabilising existing systems.
- Renovation of old mains.

- Integration work within the command areas.
- Replacement of ground source by surface source.
- Reduce wastage by adopting appropriate technology.
- Better quality surveillance.

Groundwater cannot be taken as a long-term solution. In many parts of CMA, iron and fluoride was found in excess of permissible limits and in some parts of CMA, arsenic was found. Also, in some parts of north and south 24 Parganas, arsenic contamination was found in shallow aquifers. There were problems of over withdrawal of groundwater not commensurate with recharging of the strata.

Water pricing was a must as most local bodies suffer from acute financial crunch. The problems confronting better management are:

- Adequate and timely cash flow.
- Sustainability and cost recovery.
- Inter-institutional coordination.
- Complicated and often conflicting rules and regulations.
- Multiplicity of development agencies with ill-defined scope.

The way forward was considered as:

- Harmony between political will and sound technical approach.
- Improved management of tax collection.
- Introduction of rational water rates without affecting the weaker section of the community.
- Preparation of realistic database using GIS and other appropriate high tech devices.
- Decentralisation of planning and implementation.
- Transparency, involvement and support from the community.

Crookall, David (2000) discussed that in providing safe drinking water and treating waste water before returning it safely to the environment the impact of climate change needs to be given due consideration. It is vital to ensure that all water resource developments are safe guarded against a range of possible climate changes in the future. These aspects have been actively investigated by Severn Trent Water, the leading water company in the UK.

With a view to modelling the climate change complex computer models have been used to investigate the potential impacts of rising atmospheric carbon dioxide (CO_2) levels. Assumptions were made about the pace of global warming which takes into account the success or otherwise of international action to reduce emission. Severn Trent undertook four case studies, three on surface water and one on a major groundwater aquifer.

Surface water accounts for around two-third of the company's available water resource. This is made up of a mixture of impounding reservoirs, pumped storage reservoirs and rivers. The climate model results for rainfall, potential evaporation and temperature were fed into the rainfall-runoff models for all the catchments in the case study areas. This allowed the company to quantify the range of reductions in the water resource yields by the year 2050. The surface water results show that the impact is highly dependent on the nature of the catchments and particularly on the volume of available storage.

The study on groundwater revealed that 35% of the available recharge should be allocated to support the environment to help reduce the imbalance between abstraction and recharge. Further work was considered necessary to assess the impact of climate change on the groundwater resource.

Leakage is a key component. At 18% of total water supplied, the company leakage level was considered close to the economic level. Leakage control and water efficiency come at a price.

Environmental issues associated with climate change directly affect the yield of water resources. Water companies need to provide mitigation against these changes. Under a changed climate it may not be wise to rely on historical data as the sole guide to the future. With climate change there could be more droughts and that too of more severe nature.

Dealing with climate change is no different than dealing with any other form of uncertainty. While dealing with something as complex as the global climate, it must be accepted that there will never be a perfect model. Although the precise impacts are still uncertain, there is a need to use the best information that is currently available and up to date assumptions.

Dasgupta, A. (2001) stated that groundwater is an integral part of the hydrologic cycle. Water enters the groundwater system by infiltration of surface water to the saturated zone of the aquifer. The infiltrating water passes through an unsaturated zone where the pores or voids of the soil or rock mass contain air plus water vapour in addition of water in its liquid state. Groundwater defined as only that part of the sub-surface water which is found in the saturated zone at a pressure greater than atmospheric. Water in the unsaturated zone is frequently referred as soil water.

Groundwater is more important in arid or semi-arid regions and surface water is more important in humid areas. Groundwater normally has excellent natural quality and is suitable for drinking with little or no treatment. To keep pace with rising demand, groundwater is more easily used than surface water.

Development of groundwater resources implies pumping. The location, sizing and spacing of the wells and the rate and time pattern of pumping to provide the yield that balances the demand need to be carefully planned. Observation at selected locations through observation well and judicious choice of pumping would be needed. But this would be extremely costly and would involve developing another monitoring system. Direct observation could be adopted to reduce cost.

A major constraint in national planning normally concerns water. The prosperity of a nation depends on the availability of water with living standard linked with consumption of water. Existence of groundwater is linked with topographic and geologic features of the region. Integration of ground and surface water and optimum utilisation of both appears to be the right choice. The characteristics of groundwater to be considered in planning, development and management are:

Location, Flow and Availability, Stages and Gradual Development, Energy, Quality of Water, Impact on Drainage Problems, Land Subsidence, Data, Legal and Institutional Aspects.

Development of groundwater disturbs natural, balanced inflow-outflow patterns. Major withdrawal affect large areas of groundwater reservoirs, reducing the supply in storage as water levels are lowered. These concepts of groundwater system behaviour and the sources of water pumped from wells are fundamental to groundwater interpretation and pumping application.

Under normal conditions prior to development of wells, aquifers are in a state of approximate equilibrium. Discharge by wells is thus a new discharge superimposed on a previously stable system and it must be balanced by an increase in recharge of the aquifer.

All planning for groundwater system must take into account the concepts of Safe Yield, Sustained Yield and Optimum Yield. The development should also be restricted considering environmental impact of over pumping like land subsidence and water quality degradation.

Roesaner, L A. (2001) stated that in the 1990’s the do called Best Management Practices (BMPs) have been used largely to control the pollution of urban runoff. More recently some investigations reveal that the BMPs do not protect the downstream aquatic environment and a different approach is required to protect the urban runoff. It is however felt that the problem is not the BMP themselves, but the design guide lines specified by BMPs. The impact urbanisation has on the runoff needs to be evaluated taking into account the urban growth and the constantly changing pattern and quantity of the run-off. The increased magnitude and frequency of the flow peaks can cause severe erosion and flooding downstream. The eroded sediments are deposited downstream causing obstruction to the flow and cause harm to the aquatic life in lakes and estuaries. So, the urban runoff management programme should target flow control first. Also, the design of urban drainage system should give utmost priority to flood control. The aim should be towards a holistic design of urban drainage system keeping in view improved storm water management on urban watersheds. The research should be pragmatic keeping in view the need of rapid urbanisation from a long term point of view.

Cai, X. et al (2001) discussed that, in Water Resources Management, with better undertaking of real world problems and improved data availability and reliability, researches have been developing larger and more complex models. Despite major improvement in modelling and in computing technology solving large non-linear optimisation models still remain difficult. Integrated water resources management has received large attention in recent years. The interdisciplinary nature of water resources problems require the integration of technical, economical, social, environmental and legal aspects into a comprehensive analytical framework. The hydrologic and economic components have two approaches – the compartment modelling approach and the holistic modelling.

A piece-by-piece approach has been adopted in the Cai model. The piece-by-piece approach exploits the fact that many large models can be decomposed into several small pieces that are solved sequentially. Each partial model is solved from a starting point derived from the solution of the precious piece. The decomposition of the total model into smaller models and solving each individually was found more user friendly and effective from practical point of view. The results were quick, easy to obtain and apply. Of course, the size of the problem the system can solve will depend on the capabilities of the computer and the software. However, these capabilities are being constantly improved. If there are some linear constraints these can be avoided by way sequential piece-by-piece problem solving. The piece-by-piece approved provides a method based on the currently available solvers to solve these problems formulated as holistic optimisation models.

Hayes, B.D. (2004) stated that an interdisciplinary team consisting of representation of state governments and academia developed an innovative flood risk management plan containing a large- scale non-infrastructural hazard mitigation plan with an authorised plan preciously developed by the US Army Corps of Engineers. The plan involved retrofitting approximately 1500 residential and non-residential structures in the 100–years flood plain and required a structure–by–structure development of benefit/cost analyses computer program. At less than half the cost the plan achieved flood risk management goals in a significantly more cost effective manner for an environmentally sensitive area.

Development of an alternative plan needs several innovations in flood risk management planning. An inter-disciplinary approach was taken. The plan was reviewed by an external academic review committee. Less established methods of reducing potential damages through non-structural hazard mitigation were used. Benefit/cost analysis of the plan as a whole required development of a computer program to prove the flood-proofing recommendations. The method involved setting up wet flood-proofing and dry flood-proofing structures and alternative plan was established for flood-proofing residential structures. Existing structures were elevated so that their ground floors were above the 100-years flood level. Severely damaged or highly vulnerable structures in the flood-prone areas were purchased from voluntary sellers at fair market value. A suitable computer code was developed for the proposed scheme. The code was verified and its sensitivity examined under various test conditions.

Extensive cost/benefits analysis was done under varying conditions and the flood-proofing plan was found to the cost effective.

Bhattacharya, A. K. et al (2004) stated that the work reported in the paper under consideration was aimed at conducting extensive field investigations to assess the amount of land subsidence in the Calcutta city under the effects of existing hydrological conditions and over-extraction of groundwater by pumping through deep and shallow tube wells. Based on the field data collected, the average pre-monsoon and post monsoon depths of groundwater at various locations were plotted on the city maps. A three dimensional view showing the average. Piezometric surface of the entire city was also presented in the paper. The places with the lowest peizometric levels within the city of Calcutta have also been identified. Based on the available information regarding hydrogeological and soil profiles, the extent of land subsidence at nine prime locations within the Calcutta city were estimated. A series of important conclusions were made by the authors based on the results of the entire investigation.

Also, arsenic contamination of drinking water poses the greatest threat to human health. Drinking water is derived from sources like surface water (rivers, lakes, reservoirs and ponds), groundwater (aquifers) and rain water. High concentration of arsenic is found mainly in groundwater.

Arsenic in nature is found primarily in the form of sulphides. It is mainly transported in the environment by water. Airborne arsenic is mainly inorganic. Arsenic is still sued in production of agricultural chemicals. Arsenic is also used in wood preservatives, pharmaceutical and glass industries. It is also used in manufacture of pigments.

WHO has set some guidelines on the limit of arsenic in drinking water. Some nations are trying to conform to the WHO limits. The major routes of arsenic absorption in the human body is through the digestive tract and through inhalation. Blood is the main vehicle for transport of arsenic inside the body.

A number of mitigation measures have been tried. If drinking water contains an unsafe level of arsenic it is necessary to find a safe souse of drinking water from the contaminated source. Groundwater, although largely free from harmful bacteria, may have arsenic contamination. Rain water is safe. Surface water requires more treatment than groundwater and rain water.

Some of the methods used for arsenic removal are:-

Coagulation and Filtration; Ion Exchange Resins; Activated Alumina; Membrane Method and Other Techniques. A proper technology has to be adopted to meet the particular situation.

In recent years, considerable interest has been evinced in the study of the through a porous medium, because of its natural occurrence and importance in many engineering problems. The physical understanding of flow through porous media is essential for scientists and engineers. The phenomena of saline water intrusion in coastal aquifers and seepage of fresh water into the sea, called submarine groundwater discharge, are important in this context. There always exists a zone of transition where diffusion between fresh water and saline water takes place.

Work has been conducted including a thorough experimental study involving all standard tests and model study together with theoretical analysis regarding linear and non-linear flow of sodium chloride solution through a granular porous medium.

Saline water intrusion in fresh groundwater aquifers takes place in the vicinity of coastal regions. This situation usually occurs in coastal regions having hydraulic continuity with sea when the rate of pumping in the wells disturbs the natural hydrodynamic balance. Arsenic is absent in the coastal tracts. Saline water intrusion is intense, particularly in the coastal areas as there areas are very fertile and there is intensive cultivation in winter also. Heavy extraction of subsurface water for irrigation results in an increment of chloride content in groundwater. In extreme cases saline water may come out of the tube wells. When this water is used for irrigation, salinity at topsoil is likely to take place with deposition of sodium chloride (NaCl) on the topsoil. The sodium chloride may leach downwards during the next monsoon causing saline water to enter into fresh water aquifers.

The chloride to bi-carbonate ratio is a very indicator of saline water contamination of fresh water. High chloride content in water may also be the cause if minerals containing chloride is present in the area. If the surface irrigation system is enhanced in terms of its special network and water quantity, then the stress on groundwater during the winter season will be much less resulting in adequate reduction in saline water intrusion.

Zhong, Denghua et al (2004) stated that system simulation has proved to be an effective tool for planning and improving the performance of a construction process. They made many successful case studies with the aid of 3D visualisation system applying GIS technique. GIS based visual simulation system (GVSS) was developed by the author. A hydroelectric project on the Yellow River in China which is being implemented is taken as a case study. The complex process of dam construction is demonstrated using 3D animation. This helps in quickly and comprehensively understanding the whole construction process. The GVSS is proved to be a helpful and useful tool for the design and management of construction of concrete dams.

The model enables preparation of a schematic diagram of data organisation in geographic information system leading towards effective data management. The GIS facilities facilitates a comprehensive understanding on the part of the user the topographical relationship and choose the best option amongst various alternatives of the dam locations, its height, size, and capacity of the reservoir, the dam profile, etc.

Using the simulation of the concrete dam construction the construction process and sequence has to be planned and executed to a large degree of perfection. The model is very efficient in developing schematic diagram, graphs, charts and sequential models to simulate the actual implementation in stages. Regarding mixing, transportation and placing of large volume concrete in the dam construction the model can analyse a realistic time and motion study, which can predict practical achievable time schedule for the overall construction completion. The system also helps to study alternative construction sequences and choose the best option with a view to curtail the project slippage and achieve the targeted completion time. The model enables the management to develop and issue periodic reports highlighting the key action points for effective project performance vis-à-vis the plan and can produce comparative visual charts representing the situation on quantity, cost and time.

Bandyopadhyay, P. (2004) expressed the view that water is never found pure in nature. Rain water is the nearest form of chemically pure water it contains small amounts of organic matter and dissolved minerals but less suspended matter. Water pollution is caused by addition of undesirable substances that make it harmful to man. Water pollution is also caused by deterioration in physical, chemical and biological characteristics of water caused by human activities and various other natural causes.

Water pollution is mainly caused by-

• Natural process causing decomposed vegetables, animal and weathered products are brought into the main water reserves;

• Anthropogenic process such as industrial, urban, domestic, radioactive, mining and agricultural activities by man.

Water pollution can be classified into three categories viz. physical, chemical and biological pollution of water;

• Physical parameters include turbidity , colour, odour, taste and thermal properties etc;

• Chemical parameters include pH value, acidity, alkalinity, total dissolved and volatile solids, hardness, sulphates, chlorides, fluorides, iron, non-toxic and toxic heavy metals, nitrogen and phosphates; and

• Biological parameters include thousands of biological species who spend part of whole of their life cycle in water. The most important biological pollutants are the pathogens capable of infecting/transmitting disease to human beings. These waterborne pathogens include bacteria, viruses, protozoa and parasitic worms. Most of the waterborne pathogens are introduced through faecal contamination. The coliform group of organisms is most critical as it survives and flourished outside the intestinal tract of animals.

Water quality requirements vary according to the proposed use. Water quality requirements should not be confused with quality standards. The World Health Organisation (WHO) has established minimum criteria for drinking water which all nations are urged to meet. Most industrialised nations generally have standards that exceed the WHO Standards.

Banyard, John (2004) stated that the estimated world population as on date was over 6 billion of which 1.1 billion lack in access to improved water supply and 2.4 billion to improved sanitation. Lack of clean water is the single largest cause of human illness and death. Water is implicated in 80% of all sickness and disease worldwide. Approximately 4 billion cases of diarrhoea each year cause 2.2 million deaths, mostly among children under five. The UN summit of Sept 2000 set a number of Millennium Development Goals for 2015 which include to halve the proportion of people without access to safe drinking water. The scale of the problem facing the developing and transitional countries are immense. The infrastructure assets on which many developing countries depend are reaching the end of their useful lines.

The developed countries have evolved systems of management of water supply and sewage treatment to suit their specific socio-economic requirements through re-organisation or by private sector participation. The standard of treatment achieved in the developed world is high to meet the demanding standards of EU and USA. However, in the developing countries the wishes of the environmentalists to reverse centuries of environmental pollution are likely to carry a high price. Since, all infrastructure has a finite life, over the next 20 to 50 years there will have to be a significant increase in spending on replacement of existing infrastructure compared to the level that is required today. A balance has to be struck between the increased spending on water against the competing demands of transport, energy, education etc. the challenge for water and sanitation has to be seen against this background keeping in view the overall poverty reduction. The problems of water and sanitation in developing and transitional countries are varied and no universal model can be deployed irrespective of geography and sociology.

The other challenges are climate change and water resources availability.

2.2 Management Aiming at Arresting Project Slippage

Cooke, H.B. (1980) concluded that there were five major stumbling blocks on the road to effective management, namely

1. Inability to communicate.

Generally, the only contact management has with the staffs through written or spoken words. In writing letters and memos few basic rules must be observed. The rules are:

Rule 1 – One subject per letter.

Rule 2 – Start with a short paragraph stating why you are writing the letter.

Rule 3 – Follow with one or two short paragraph stating what your want to say.

Rule 4 – Finish with a short paragraph stating "Unless I hear from you by this date I will go ahead on my own.

Rule 5 – Use only short words and short sentences throughout.

Improve your oral communication with a brief and clear description of the problem.

2. Inability to understand chain of command-

Study the organisation in which you are involved and practice observing the chain of command. You can accomplish work activities much quicker and more effectively.

3. Inability to establish properties-

It is human nature to do first what we like to do best and leave less interesting assignments to be done later. Unfortunately, top priority are normally those things we would rater like to postpone.

4. Inability to follow-up-

Most people do not do a whole job on their own and want follow-up in their areas of responsibility. The critical details must be totally and closely followed up. Blaming poor delivery for failure to complete the job in time is not acceptable.

5. Inability to empathise-

Empathy means the projection of yourself into another person's world i.e. putting yourself in his or her shoes. Each supervisor has his or her own ways of doing things. You should understand and respond without compromising your ideas. Never ask your supervisor to establish priorities for you.

These are just five of the major pitfalls along the road to project success. None, of them should stop you if you approach than correctly and work continually towards improvement.

Parker, R.F. (1985) discussed the usefulness of meeting vis-à-vis the actual work and suggested ways and means to make the meetings more productive. Meetings are a major time waster and the time they waste is frequently the most costly, the time of the top executives who at times spend as high as 75% of their time on the job on meetings. Meetings however, are inevitable in business and just about as popular. The paper discussed methods whereby the time-wasting characteristics of meetings can be greatly reduced if not completely eliminated.

Every meeting generates a host of little follow-up meetings, some formal, some informal, but both stretching for hours. Meetings, therefore, need to be purposefully directed. As a rule, meetings should never be allowed to become the main demand on an executive's time. The following possibilities were considered.

1. Reduce the number of meetings by eliminating and/or combining meetings.

2. Ensure that meetings achieve the desired results – agenda and follow-up.

3. Shorten each meeting – have a schedule and stick to it.

4. Reduce the number of participants.

5. Implement a rigorous and effective follow-up.

Business meetings can be classified under by purpose, by frequency, by protocol observed and by attendance. Meetings with stakeholders and board of directors are not in these categories

The purpose of a business meeting will include:

To disseminate information, to advise, to assemble and coordinate information, to formulate policy, to coordinate activities, to encourage creative thinking, to educate and to make decisions.

The frequency of meetings include periodic and regular meetings. The frequency of project staff meetings depend on the nature of the project and modus operandi of the project manager or group leader. It is better to have frequent meetings of short duration rather than fewer meetings which drag on for hours.

Regarding protocol, meetings can be formal and informal. Formality is essential to the conduct of large meetings. Every meeting should have at least the following – A purpose, An agenda, A leader or Chairperson, A schedule, A secretary or recorder and Follow-up. An Agenda should include:

1. A brief statement of the purpose of the meeting.

2. A list of topics to be discussed.

3. A schedule of the allotment of time for each topic.

4. A statement of the results expected.

The person chairing the meeting should have the following qualifications:

1. Objectivity.

2. Ability to elicite comments and reactions from others.

3. Ability to control the discussion.

4. Ability to summarise the discussion of others without personal bias.

5. Ability to stop, to change topics, to adjourn the meeting.

6. Familiarity with the subjects to be discussed.

7. An interest in the outcome of the discussions.

The essential elements for a good follow-up include:

1. Minutes of the meeting.

2. Summary of actions.

3. Designation of responsibility for action.

4. Rechecking progress of action.

Apart from the chairperson each meeting must have an expeditor who should act as the task leader.

Executives reportedly spend more than 75% of their time in meetings and are evaluated as not more than 25% efficient. The real issues on which meetings are held could usually be handled in half the time actually spent and with half the personnel involved. More than 50% of many executive's time is, for all intents and purposes wasted. Executives having more demanding jobs are therefore, forced to either work overtime, neglect some of their duties, or delegate duties to subordinates which they should handle themselves.

Tarricone, P. (1992) expressed the opinion that some engineers are born leaders but most managers are created. In the real world, managers evolve in a variety of ways. There is no perfect blueprint for creating managers. Management education should start after several years of practical training and experience. The primary degree should be technical and formal management training should follow. The study of engineering management must cover project, organisation and global management in that order. Management skills are frequently learned in a variety of ways and at different stages of the engineer's career.

Managers can be made in at least four ways:

- Undergraduate training.
- Graduate and continuing education classes;
- Employer in-house training programmes;
- On-the-job or state-of-the-art experience.

The technical programme is supplemented by course work in accounting, finance, marketing, computer science and technical writing. It is imperative that you become a civil engineer before you become a civil engineering manager. A manger's communication skills are also important and should be developed early in his career. He needs to talk to the clients. Producing a good design report is just not enough.

What does a manager do? He manages events and people, but basically people. To become a team leader the engineer must attain a certain level of technical competence. Agencies in both public and private sectors have developed sophisticated in-house training to prepare their engineers for management responsibilities. The days of the best technical person automatically becoming a project manager are gone. Good technical skills however, do not necessarily equate to good managerial skills.

Engineers have to learn as they go ahead in their career path. There is no automatic changeover to a manager. A formal managerial education or in-house management training is called for along with growth of technical expertise. A manager in the construction industry has to be an engineer first and then a manager.

Kerzner, H. and Kerzner, J.E.B. (1992) stated that growth and acceptance of project management will continue for the next twenty years. The success in a project must confirm to the following constraints:

Within allocated time; Within the Budgeted Cost; At the Desired Performance, Technical or Specification level; and with Acceptance by the Customer User.

Most project management practitioners view management as an art rather than as a science. The key to successful maturity to project management lies with the line managers. Project Managers must be accountable: Accountability = Responsibility + Authority

In mature organisations, contrary to popular belief, the project manager does not have the authority commensurate with responsibilities. Rather, the authority rests with the line managers who have direct control over the resources.

The most critical phase of any project is planning. If the project is planned correctly, the likelihood of success increased dramatically. To improve the planning, the recommendation is as follows:

- Develop a life-cycle phase approach to planning, scheduling and controlling;
- Manage the lifecycle.
- Insist that project managers have well-defined audit trials.
- Discourage micromanagement and replace it with line management, trust and cooperation.

To achieve excellence in project management, what it can and cannot be expected to achieve;

- Executives infuse project management with realism.
- The project manager is not viewed as a scapegoat. Project management does not mean that budget and schedule will always be met.

- Problems are being solved by brainpower rather than through additional funding.

Melanson, C. (1998) expressed the view that human resource management is one of the major aspects in project management. One of the first step required is choosing a project manager (PM). This is an extremely important decision. The PM must possess the skill of a leader: honestly, integrity, enthusiasm, courage and optimism. With effective leadership, the project manager can get full commitment from all team members.

In sitting up the project organisation selection of hardware, purchase of software, development of programs and documentation, installation of computers and training of personnel need careful consideration. Three types of organisations could be considered:

1. Functional. 2. Project. 3. Matrix.

Functional organisation depends on staffing by departmental personnel. Project organisation staffing can be done by recruiting people from within the company or from outside. Matrix organisation is a combination of pure project and functional forms. All the three types have advantages and disadvantages.

In selecting one of the above organisations the following steps need to be considered:

- Objective and expected outcome.
- Determine key tasks and required resources.
- List of special characteristics.

Selecting the team members is another important phase. In this selection the project manager should look for – high quality technical skill; political sensitivity; strong problem orientation; strong goal orientation; high self-esteem.

In team building, the PM should look for the following:

- Develop a realistic priority level
- Share expectations
- Develop a relative priority level
- Share expectations
- Clarify goals
- Establish operating guidelines.

Clear face-to-face contact helps in holding the group together. It creates a team identity. Teams function well when there is a clear role definition; careful time control; sensitivity among members, a relaxed atmosphere; commitment; self- assessment; reward for effort and recognition for results.

Another important aspect is conflict resolution. PM's 20-25% of their time resolving conflicts. Communication is a major aspect for the PM. The PM must remain honest, confront the situation immediately and keep the communication lines open to minimise rumour and provide support to the team.

Kibert, C.J. and Coble, R.J. (1995) stated that many construction safety issues are closely related to environment problems. He suggested consideration of safety and environment regulations at federal and state levels partially or totally to provide uniform and accurate guidance and avoid unnecessary duplication. This would eliminate unnecessary conflicts and result in substantial cost saving. The feasibility of consolidation the regulations of construction health and safety with environment protection in the light of improvement in efficiency should be seriously considered. Pollution of air, land and water; destruction of animal habitats and high noise levels are effects that lead to a reduction in quality of life and threatens the human race. In a broad context, environmental issues are basically safety issues. The construction industry should be fully aware of this connection. The use of hazardous materials in construction is a major issue that affects both environment and safety. The common paths of hazardous materials entry into the human body are:

1. Inhalation of substances like ammonia and asbestos fibre
2. Skin absorption of substances like gasoline, mineral spirits, toluene and pesticides
3. Swallowing of toxic substances.
4. Injection of hazardous materials.

Pollution of water and wetland due to construction activities is a major hazard and must be eliminated. Oncoming regulators will require careful control and recycling of solid waste. It is necessary to expand the education of construction professionals on environmental and safety issues. The process of change must be initiated immediately to modify the method of handling of environmental and safety issues at the construction site.

Pinto, J.K. (1996) expressed the view that power, politics and project management are three processes that although very different are closely linked. No one can go very far in project management without understanding this links. Too much depends on the manager's ability to effectively manage not only the technical side of the job, but also the behavioural side as well. Here are some of the steps project managers can effectively take, namely

Understand and acknowledge the political nature of the organisation. Before managers are able to learn to use politics to support the project implementation, they must acknowledge its existence and its impact on the project success;

Learn to cultivate appropriate political tactics for effective negotiation and bargaining. Some experts believe that through the combined efforts of all organisational factors it is possible to eradicate the political nature of companies and government agencies.

- Understood and accept WIIFM i.e. What is In It For Me?
- Try to provide project managers with some "equal footing".

• Learn the fine arts of influencing.

• Develop your negotiating skills.

• Negotiation is sometimes a distasteful part of the project management process. Project managers are forced to negotiate daily. But except for some seasoned project managers who have developed their skill the hard way, most are uncomfortable with the process. Further, because they find it distasteful,, they have never sought to improve their skills or learn new techniques.

Conflict is a natural side effect of project management. Many managers react to conflict with panic. Project managers need to better understand the dynamics of the conflict process. Each situation must be dealt as a unique event. There is no one best method to deal with conflict and project managers need to be flexible in their approach.

Gioia, J. (1996) analysed and found that no programme is immune from failure. The name of the game risk; schedule risk, cost control risk, communication risk, change control risk, and poor implementation risk. The programme manager must identify these potential risks and present or overcome them to ensure success. Twelve fundamental reasons have been identified.

#1: Underestimating programme Complexity-

Underestimating complexity leads to poorly detailed management plans.

#2: Lack of Access and Internal Communication-

Without deep insight into all factors the programme manager is at the mercy of unforeseen influences. The programme manager must be granted the authority to proactively manage these influences.

#3: Not integrating the key elements-

Years ago, programme managers concentrated on managing schedules. Now cost control and configuration management are universally recognised as key management process;

#4: No Measurable Controls-

How do your know when your programme has succeeded? Most organisations fail to build such metrics into the programme plan;

#5: Requirement Creep-

This refers to adding new requirements of introducing changes, which move the programme further from the original Statement of Work (SOW). Requirement creep typically results in delayed scheduling and spiraling cost;

#6: Ineffective Implementation Strategy-

Implementation is the key to success. programme success hinges on two fundamental concepts: a high quality plan and effective implementation;

#7: A software tool is not the only answer-

A software is a necessary component to the solution, but the software itself will not manage the program;

#8: Contractor and Customer have Different Expectations-

Both parties must act as a team with a singular vision for success. Both parties stand to lose without this vision of success;

#9: No Shared “Win–Win” Attitude-

Contractor wants to use the programme for generating more revenue the customer relies on the contractor to deliver. Both are destructive to the programme.

10: No Formal Education-

Programme management and implementation is highly specialised technical discipline and requires experts with formal education-

#11: Lack of Leadership Commitment and Sponsorship makes it a top priority and broadly communicate their sponsorship across their organisation.

#12: Not viewed as a startup business-

Too often new programmes are viewed as an extension of another project instead of being seen as a startup business.

Understanding these twelve fundamental reasons is invaluable to avoiding failure in future programmes.

Black, K. (1996) narrated his findings on a survey of 70 professional engineers conducted in December, 1994, and concluded that there are at least a dozen distinct reasons for project failure and presented it in an Ishikawa diagram. The causes are:-

Planning: The most important key to a project success may be planning. Project definition and scope are critical. Many projects are not adequately defined at the beginning. Planning can be improved with the involvement of key players right from the start.

Change: Change is a major cause for failure. Initial planning may not be complete, unforeseen difficulties arise, financial problems etc. project changes result in cost increase and schedule modification.

The Project Manager: Failure may arise due to project manager unwilling to take decision; poor management by the project manager; failure of the project manager to delegate etc.

Scheduling: Project Scheduling is the key variable. It leads to increased cost; lack of coordination; delay or slippage in the project etc.

Management support: lack of support and involvement of the top management is a major cause of failure. Over- involvement of upper management leads to undermining the authority of the project manager. The upper – level management should act as a facilitator for the project.

Funding: Improper and inadequate funding leads to failure. The fund flow should be smooth as per project needs.

Cost Containment: Failure to contain cost often occurs because of changes in scope. The project manager should exercise restraint in containing the cost. Slippage in the project leads to cost escalation due to inflation.

Resources: Resources like human, equipment and facilities are determined at the planning phase. Optimum human resources must be deployed. Over-assignment of human resources can slow down the project as there will be too many people with too little work.

Information Management: Poor information management is a potential cause of failure. This includes flow of memo to high-end project management software. Lack of quality feedback and poor coordination with vendors are cause of failure.

Incentives: The system of rewards for good performance and penalty for poor output should be incorporated. Motivation is a must for successful completion of the project.

Risk Analysis: This should be an essential item in the planning process. Failure to assess the risk is a potential cause for project failure.

Other Reasons: Commitment and reliability of suppliers is serious concern. The supplier is a project team member and most understand the importance of timely delivery in the overall project completion. Government involvement and involvement of the community are also very significant factors.

Many of these causes are interwoven and inter-dependent. The survey suggests that the stakeholders should be closely involved in a very thorough planning process. Also realistic goals and objectives are to be set right at the beginning.

Haransky, S. (2000) indicated that designers have been increasingly taking on the role of project managers. Since designers are trained as problem solvers, they are often found to be capable of solving problems in the management side as well. Unfortunately, many engineers have inadequate business training for managing projects, staff or clients. Finding the right person for a management position can be challenging, but with the proper assessment, training, mentoring and feedback, designers can develop the acumen to solve business problems as well.

To help designers become skilled in this area, the employer must devote the time and expense necessary for thorough management training. The required skills might include financial management, budgeting, estimating, productivity assessment, time management, effective communication – both oral and written, and the ability to build the consensus in a team and to negotiate. Such characteristics might include working with others and having a strong work ethics. Determining the individuals behavioural style nearly in the process will help in designing the training programme that works best for each type of person. New managers must be taught the principles of sound management before assigning definite responsibilities on them.

Managers need to have the power to make decisions and stand by them. Manager must depend on subordinates to take on more responsibilities and to make decisions. Instituting a programme to groom manager is vital for the performance profitability, and competitiveness of the employer company. The employees will recognise that the company provides opportunities for growth and development and they will stay with the company.

The cost of training and development can be high, but given the alternatives – faulty budget and estimates, poor productivity and time management, and mediocre negotiation and presentation skills – it may very well be a minimal investment for maximum return.

Basak, S. and Bhattacharya, A.K. (2004) expressed the view that success in a civil engineering project depends on the performance of individual members in the project term. Adequate measures have to be taken to motive workers at various levels to achieve success in the project. Various models and theories of motivation have been discussed. The basic needs considered are:

- Physiological: food, clothing, shelter etc.
- Security and stability of job and earning.
- Affiliation: companionship, belonging to a group, etc.
- Ego – need: self esteem, social recognition, etc.
- Self activation: independence, status, position, power, etc.

Any civil engineering project like hosing, urban development, highways, bridges water resources development, environment etc consists of design, development, execution and completion. Each one of these need the active participation of specified personnel. A project is viewed as a term game and success depends on each player playing his part well in a fully coordinated manner. It is essential to put the right man on the right job. Each member must have his duties and responsibilities will defined with a well-identified superior and one or more subordinates. Worker's motivation depends on the level to which the worker belongs. The suggested guidelines are:

- Bottom level worker – motivated by special monetary incentives., accidental coverage, etc.

• Middle level worker – motivated by affiliation and stability such as service security, retirement benefit, appreciation from superior, etc. apart from direct monetary gain.

• Top-level employee – motivated by getting importance, more power, promotion, awards and recognition.

Investigation of failure of projects reveal that the causes generally are not technical or financial shortcomings, but insufficient personnel management. While motivation of workers is a must, frequent motivation does not necessarily lead to accelerated output. This calls for a balance between expectation and fulfilment. The motivation must be optimum to derive the maximum output. The workers have to be given a proper working environment as well as incentive rewards. Also, the employees have to be motivated with power, promotion awards and recognition.

2.3 APPLICATION OF MANAGEMENT TECHNIQUES IN WATER RESOURCES, ENVIRONMENT AND INFRASTRUCTURE PROJECTS:

Morris, P.W. (1980) viewed the project management scenario for the next 20 years. DuPont developed the CPM schedule in 1957 followed by U.S. Navy who developed PERT in 1958. Since then there was explosive growth of project control system – projects became more complete technically and organisationally; computing capabilities increased dramatically and complex, innovative project organisational form emerged. Selection of appropriate control technique also became more complex from initial planning to progress monitoring and review. The characteristics of good system were:

• That it provided timely data

• Appropriate to the user's needs.

• A system of good quality, easy to adopt and apply;

• Data must be compatible and convenient to integrate subsystems.

• Cost should be reasonable and affordable. Planning and control department was responsible for:

• Integrated cost and schedule systems.

• Automatic cash flow forecasting.

• Identification of three major reporting levels.

• Integration of project accounts code with engineering drawings, procurement and finance.

In many instances, informal controls and simple systems are the most appropriate control mode. Sophisticated control systems are most beneficial in strategic monitoring of large, technically complex projects. Satellites have been beaming data between project offices around the globe.

Sophisticated project control systems are difficult to install because of technical complexity, cost, time needed to train the personnel and consequently the time needed to start getting the results. Implementation of such complex systems must be phased to the needs of the project as a whole.

Slevin, D.P. and Pinto, J.K. (1986) advocated a new tool for project managers – The Project Implementation Profile (PIP) which should help to better monitor and systematically oversee the status of the implementation. Development of PIP represented an area for future fruitful research.

Project management is a complex process involving simultaneous attention to a broad variety of human, budgetary, and technical variables. While numerous models have been developed providing technical support for the project manager (such as critical path modelling, spreadsheets, activity flow charts, etc.) a great need existed for a model to address the human and managerial aspects of successful project management. Ten critical factors are of great importance for the project success-- these are defined as follows:

1. Project Mission – clarity of goals and general direction.

2. Top Management Support – Willingness of top management to provide the necessary resources, authority and power.

3. Project Schedule/Plan – A detailed action steps required.

4. Client consultation – Communication and consultation with concerned parties.

5. Personnel – Recruitment/training of project team.

6. Technical Task – Availability of required technology and technical steps.

7. Client Acceptance – The act of selling the final project.

8. Monitoring and Feedback – Timely provision of control information

9. Communication – Provision of necessary data to all the key players.

10. Trouble-Shooting- Handle unexpected crisis and deviation from plan.

The PIP model was tested on a number of test cases and the success/failure rates were recorded. The Percentile Rankings were as follows:

1. Project Mission

80%

2. Top Management Support

74%

3. Project Schedule

59%

4. Client Consultation

61%

5. Personnel

86%

6. Technical Task

89%

7. Client Acceptance

49%

8. Monitoring and Feedback

62%

9. Communication

77%

10. Troubleshooting

81%

The new tool project implementation profile (PIP) was recommended for use by Project Managers for greater project success.

Curmudgeon, O. (1994) expressed the view that failure to plan the project carefully could result in excessive rework and large delay in completion. Failure to communicate the plan could lead to confusion and uncoordinated efforts. Finally, these could lead to both schedule and budget occurrence. The final representation of the plan can be driven by a project network diagram based schedule.

Work Breakdown Structure (WBS) is like a family tree of project components that organises and defines the total scope of the project. Each descending level represents and increasingly detailed definition of a project component. The primary purpose of WBS is to aid the project consists of the sum total of all the elements of the WBS. WBS should not be used as a financial accounting tool. WBS must focus on the work to be accomplished to complete the project.

Sequential relationship between elements, work packages or activities is not shown in the WBS. Each element in the WBS should be the clear responsibility of a single individual. Use specific name and titles. Involvement in planning leads to motivation to perform to the plan. Also, WBS is a communication device. WBS is the means for the project manager to define the strategy by which the project will be performed.

The project manager should primarily be concerned with the work at Level 1 of the WBS. The project manager should prepare more than one alternative WBS down to the third level. Analyse the pros and cons of each.

While WBS is an essential element to provide stability to a project, it must be recognised that projects are used to manage change. Consideration should be given as to how changed requirement and work content would be incorporated into the approved WBS. Change control is an essential requirement in project management. Change itself creates many problems in projects.

Kliem, R.L. (1996) gave his views on project management and re-engineering. In a broader sense, project management is the knowledge, tools and techniques to lead, plan organise and control projects. Leading, planning, organising and controlling are the basic process of project management.

- Leading means motivating people to perform satisfactorily.
- Planning means determining in advance what the project will achieve.
- Organising means arranging resources in a manner that expedites the achievement of goals.
- Controlling means determining how well a project is progressing according to plans and taking corrective action, if necessary.

The main contributors to project failure are:

- Changing requirements and specifications.
- Incomplete requirements.
- Lack of executive support.
- Lack of IT management.
- Lack of planning.
- Lack of resources.
- Lack of user involvement.
- Lack of knowledge on the technology.
- Unrealistic expectations from the project.

The Statement of Work (SOW) has to be drawn up which will define the goals and objectives of the project. Planning process is widely known but not applied very well. Work Breakdown

Structure (WBS) is an effective planning tool. It is a top-down listing of tasks to be performed to complete the project. WBS forces all project participants to be specific and accountable for their own tasks and enables better tracking of people's performance. WBS makes it possible to detect slippage in task and to evaluate the impact it will have on the subsequent tasks.

Knowles, R. (2001) expressed the view that when things go wrong on a project site, problems generally do not come one at a time – but all at once. Concurrent delay is a common phenomenon in construction projects. It is not uncommon for work to be delayed due to factors like defective work, late instructions from employer/engineer and exceptionally adverse weather, all occurring at the same time. Contractually, the contractor is entitled to more time but no extra payment for bad weather; extra time and additional payment for late instruction; and neither extra time nor cost for defective work.

Standard forms of contract provide no help and no help also from recorded legal judgments. One approach is as follows;

If one of the competing causes of delay were a breach of contract on the part of the employer or the engineer, the contractor would be entitled to an extension of time and additional payment.

The other approach is the dominant cause approach: Where there is more than one cause of delay, one delaying event could be more influential than the others. That means one cause of delay affects a greater area of work than the others. Hence, the contract would be adjusted in terms of granting an extension of time and more payment, if applicable.

The burden of proof of the dominant cause for delay lies with the contractor. If the cause of delay is due to breach of contract on the part of the contractor, the contractor cannot escape the consequences, i.e. his obligation to pay liquidated damages to the employer.

It is commonly observed that at times both the employer and the contractor are causing delays, both occurring at the same time. Such delays may be constructed to nullify one another. While there will be a delay on the project, it will be attributable to none.

Where delays are running in parallel, the cause of delay that occurs first in terms of time will be used for adjustment of the contract period.

A contractor who is seeking an extension of time must be able to show that the concerned delay is one the critical paths and it may result in extension of the project completion time.

Where more than one delaying factor is on the critical path and appears to be affecting the completion time the dominant factor and the agency responsible must be identified and action taken accordingly.

Jung, Y. and Woo, S. (2004) discussed the fact that engineers have shown great concern over the integration of cost and schedule control systems. However, the integration of these two control systems have not been popular in real life so far. One of the major obstacles has been the collection and maintaining the data.

Cost schedule and quality are the three major measures for construction project performance. Cost and schedule are objective while quality is subjective and qualitative. Cost and schedule are interrelated as they share a lot of common data. So integration of cost and schedule is possible. Most researches have not addressed this issue in details. The paper proposes a flexible Work Breakdown Structure (WBS) that allows us to assign different management approaches for different work packages.

Integration of cost and schedule control system will contribute immensely to the overall project management information systems. Control Account (CA) is a management control system aims at integrating the WBS and CA for effective control and management. The level of detail is critical in integrating the two systems. The traditional WBS adopts rigid structure. The integration of the two control systems is practicable with a flexible WBS. The paper illustrates this flexibility with a number of case studies. A separate system of numbering and coding has to be adopted in a flexible WBS. Also, a special system of evaluation measures need to be adopted in flexible WBS.

Flexible WBS can be most effectively utilised when the characteristics of each Work Package (WP) is thoroughly perceived and the management plan is well defined at the beginning of the construction project. The author believes that the concept of integration of cost and schedule control through flexible WBS should increase worldwide for construction organisations. The technique can also help in maintaining valuable historical data for permanent reuse.

The present author opines that in all projects of water resources and infrastructure, the engineering aspects of the project must be taken up right in the beginning. These include collection of raw data, site selection, feasibility study including alternative processes and selecting the optimum one, techno-economic evaluation, working out cost/benefit ratio, funding pattern, cash flow requirement, resource requirement and availability, basic work plan and conceptual design of the project.

Some researchers in the United States of America have suggested innovative mathematical models on the basic PERT/CPM techniques (Ref: Project Management Journal, Vol XXIII, Number 3, Sept. 1992 pp 5-16).

A group of projects were considered. For each allocation of resources there were eleven delay times represented by the vector D.

D = (d1, d2, d3 ………………………….. d11)…………………..[1]

The projected income vector for all the projects, G, was

G = (g1,g2, g3……………………………g11)…………………[2]

Seven separate resources were considered. The resource vector R was defined by the resources added or changed in each condition,

R = (r1, r2, r3……………………………r7)…………………… [3]

and the sales required to support each added resource was S,

S = (s1, s2, s3……………………………s7)……………………[4]

The total delay cost was the inner product of the delay time and the projected income plus the inner product of the resources used and the sales cost of those resources:

f(z) = D.G+R.S……………………………………………………[5]

The objective could be restated as : minimise the value of the objective function, f(z), the net delay cost of the eleven projects.

The present author recommends using WBS for listing of activities and work packages and assigning responsibilities on specific persons within the organisation. The author is of the view that good deal of control can be exercised on the project by developing WBS in good detail and following up the project closely. The author recommends that the activity network be developed by proper interfacing of the activities in the WBS. The author prefers the PDM form of network presentation vis-à-vis the traditional form - ADM.

On the aspect of arresting slippage on the project, the recommendation is to take up the following steps, namely,

Delay Identification ,

Delay Quantification,

Delay Analysis,

Problem Analysis, and

Corrective Action.

On application of the corrective action the project response to the applied action has to be measured and, if necessary, action has to be revised till the desired result, that is, minimising/eliminating the delay is achieved. It must be understood that it is the natural tendency of a project to get delayed. Even after arresting the slippage on one path, i.e. one chain of activities, the chances are, the project will get delayed along another path. The syndrome of concurrent delay also needs to be tackled. Delay does not occur in isolation, they come in bunches and in battalions. So, tackling one delay at a time may not yield any tangible result.

3 CONCLUSION

Arresting slippage in projects, particularly those related to water resources, infrastructure and environment involves identifying, evaluating and managing project delays. This forms an integral part of the overall management functions of the projects. Unmanaged delays get more and more pronounced and ultimately lead to cost and time overruns. At the outset, a computerised database must be established. The basic engineering of a project such as feasibility report, study and evaluation of alternative processes and routes, site selection, land acquisition, survey and soil investigation, site preparation, etc. must be taken up. This must be followed by the arrangement of construction facilities like construction water, construction power, construction storages, construction housing, etc. Detailed design and engineering should follow. All management systems of the project need to be based on activity networks developed on the basis of detailed work breakdown structure (WBS). Analysis, monitoring, feedback data collection and reporting must be done with application of computer with appropriate software on project management. A well defined and systematic methodology of delay management should form an integral part of the computerised system. The system of recording delays, apart from helping in control of slippage, has proved to be useful in setting contractual claims and disputes. Also, the system of Delay Analysis and Problem Analysis have been found to be effective in exercising adequate control on the project execution with respect to the schedule, budget and the contract. The author recommends the application of these innovative methodologies in complex projects like water resources development, infrastructure and environment. The recent ongoing advancements in information technology (IT) and telecommunications have been a great boon to engineers and planners involved in the management of multi-disciplinary development projects. Communication and data transmission have become much faster and accurate. The physical distance between the project office and the site has practically disappeared. The management must make use of these high-tech applications to the best advantage in order to arrest project slippage.

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