SEDIMENTATION ISSUES OF HISTORICAL CAUVERY IRRIGATION SYSTEM IN INDIA

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Abstract

The sacred Indian river Cauvery commences its journey in the hillocks of Karnataka state near Mysore and empties in Bay of Bengal adjacent to famous Tranquebar in Tamil Nadu flowing about 765 km.. The river system is a source for agriculture , drinking water and hydro power. The irrigation is regulated in Tamilnadu state through five regulators out of which Grand anicut constructed in 2nd century is of historical importance. After Grand Anicut it divides into numerous branches forming vast network of irrigation channels. The mighty Cauvery river here is reduced to an insignificant channel and enters the Bay of Bengal. Cauvery flowing in Tamilnadu state is very wide resulting low flow velocity. This results in sediment accumulation and it was necessary to assess the quantity. The computations require hydraulic parameters. HECRAS software was adopted for assessing the hydraulic parameters. This paper presents the methodology adopted, and suggestions on sedimentation issues of the historical Cauvery irrigation system.

Key Words: Basin, Regulator, sedimentation

1. INTRODUCTION

Cauvery river flows in South Karnataka and then to Tamil Nadu. Cauvery is one of the major rivers of India, which is considered sacred by Hindus. The Cauvery River basin is estimated to be 27,700 square miles (72,000 km^2) with many tributaries including thc Shimsha, the Hemavati River, the Arkavathy River, Honnuhole River, Lakshmana Tirtha River, Kabini River, Bhavani River, the Lokapavani River, the Noyyal River and the Amaravati River. Rising in southwestern Karnataka state, it flows southeast some 765 km covering states of Karnataka, Kerala, Tamilnadu and Pondycherry and enters the Bay of Bengal. The river system is a source for agriculture and hydro power. The river enters Tamil Nadu through Dharmapuri district leading to the flat plains where it meanders. The river passes through Dharmapuri, Salem, Namakkal, Karur, Trichy, Thanjavur, Thiruvarur and Nagapattinm districts in Tamilnadu. At Karur the river becomes wide, with sandy bed, and flows in an easterly direction until it splits into two at Upper anicut or regulator located about 14 kilometres west of Thiruchirappalli City. The northern branch of the river is called the Coleroon or Kollidam while the southern branch retains the name Cauvery and then goes directly eastwards into Thanjavur District. These two rivers join again and form the Srirangam Island which is a part of city of Tiruchirapalli. The Chola king Karikalan has been immortalised as he constructed the bank for the Kaveri all the way from Poompuuhar (Kaveripoompattinam) to Srirangam. It was built as far back as 1,600 years ago or even more. The Kallanai dam constructed by him on the border between Tiruchirappalli and Thanjavur is a superb work of engineering, which was made with earth and stone and has stood the vagaries of nature for hundreds of years. In 19th century, it was renovated on a bigger scale. The name of the historical dam has since been changed to Grand Anicut and stands as the head of a great irrigation system in the Thanjavur district. From this point, the Coleroon or Kollidam River runs north-east and discharges itself into the sea north of Tranquebar.

Figure 1shows the route of Cauvery river in India.

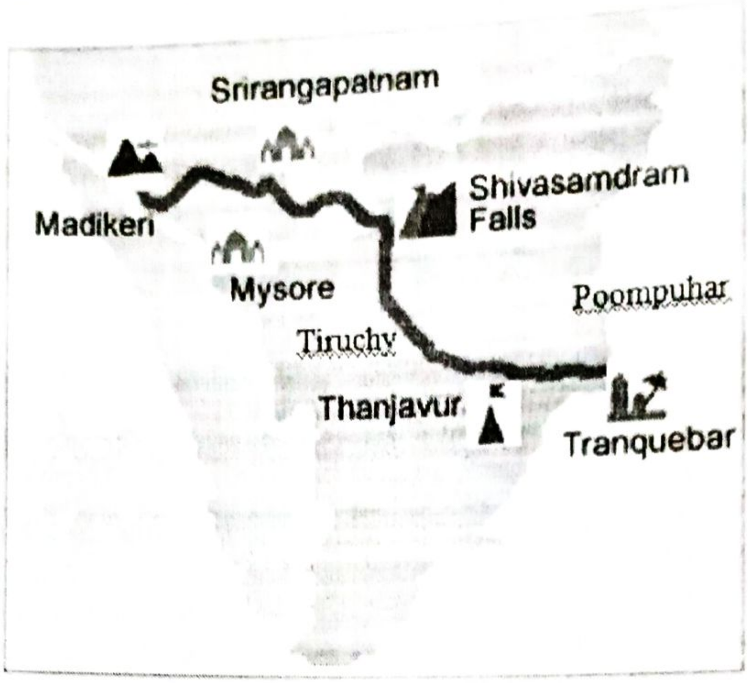

Fig 1. Cauvery river course

The Grand anicut is constructed on the main Cauvery river. At Grand Anicut complex, the river Cauvery splits into two branches Cauvery and Vennar . These two rivers act as the main irrigation canals with the help of head regulators provided on the both the rivers separately. These rivers in turn, divide and sub divide into number of branches which form network all over delta and distributes the Cauvery water in the vast irrigation system. These channels also carry the drainage water and act as irrigation cum drainage channels in the lower delta. After Grand anicut, the river Cauvery divides into numerous branches and covers the whole of the delta with a vast network of irrigation channels in Nagapatnam and Tiruvarur districts and gets lost in the wide expanse of paddy fields. The mighty Cauvery river here is reduced to an insignificant channel and enters the Bay of Bengal 13 km north of Tranquebar. The Cauvery delta formed is in the shape of triangle with its base measuring 100km in north-south direction and its apex at upper anicut located 160 km west of coast. There are 36 streams along deltas measuring 1606 km. Mohanakrishnan (2011) estimates the irrigation in the beginning of 19^{th} century as 600000 acres. The first improvements were done by British engineers in 1809 and subsequently by successive governments; the total irrigation was increased to nearly 1000000 acres. The important irrigation regulators located along the study which are used for the regulation of water along the reach are Jeddarpalayam barrage, Mayanur barrage, Upper anicut, Grand anicut and Lower anicut.

Each of these anicut has their own command area and irrigation is regulated through them. The source of irrigation is from Mettur dam located upstream. The location of the anicut along Cauvery and surplus course Kollidam are detailed in Fig 2. Finally all the streams of Cauvery and Kollidam confluence with Bay of Bengal.

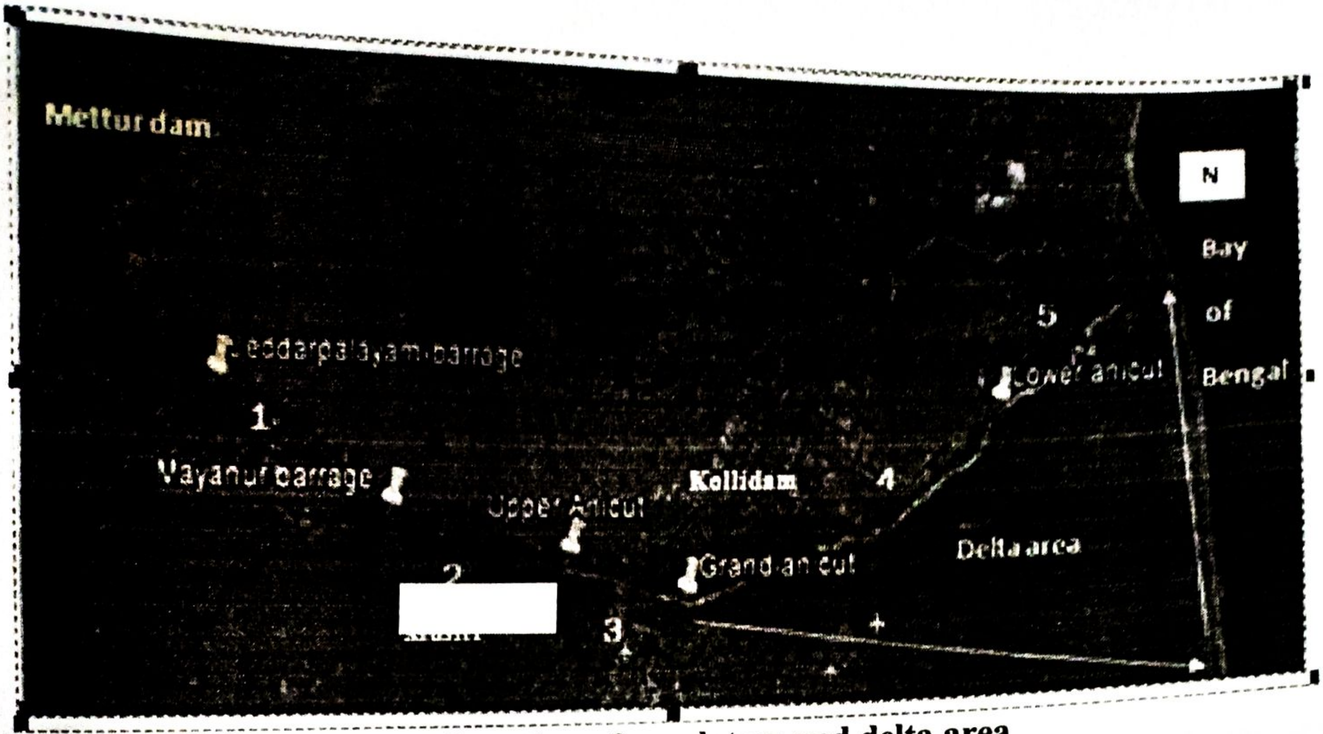

Fig 2. Location of regulators and delta area

2. OBJECTIVE OF PRESENT STUDY

Cauvery river receives flow from Mettur dam . The reach from Jeddarpalayam anicut to Kollidam river is very wide resulting low flow velocity. This results in sediment formation and it was necessary to assess the quantity. Most of the time in a year the river in the study reach has water flow for irrigation. During South West monsoon it receives flow from the upper catchment in Karnataka and in North East monsoon the flow is from catchment in Tamilnadu. Along Cauvery, during heavy rains in the upper catchment of Mettur dam, the flow can be excessive and the surplus water is diverted through a wide waterway called as Kollidam. Due to flat slope and large river width, the flow velocity will be mostly low (about 1m/s) resulting in sediment formations along the bed of the rivers Cauvery and Kollidam. The sedimentation has resulted in decreasing the carrying capacity and efficiency of regulators in diverting the flow of water to the side channels as shown Fig 3 and 4. Hence sand mining was permitted in the river. The sand mining activity is limited to middle reach of the river. The sand mining activity is done at ***"1m below original bed and removal of shoals above the bed".*** Hence the study was conducted to assess sediment formation in Cauvery under different flow conditions.

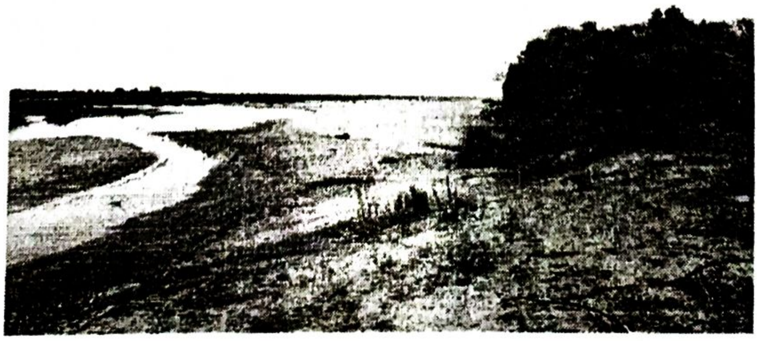

Fig 3. Sediment formation in channel

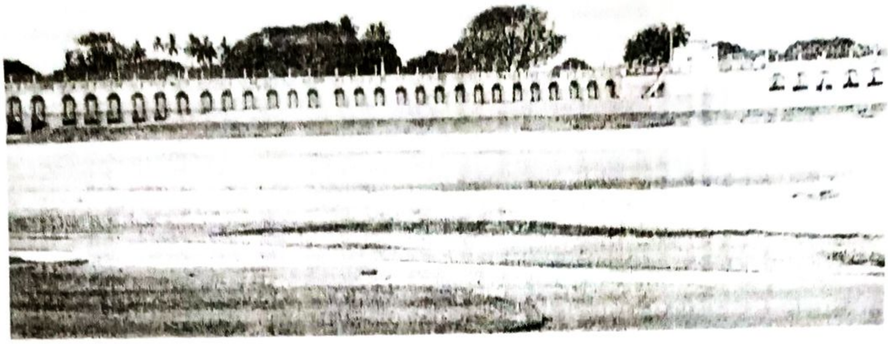

Fig 4. Sediment formation on upstream of regulator

3. METHODOLOGY

The following are the details of the procedure adopted for the estimation of sediment

- Collection of available field details on discharge and sediment
- Calibration and evaluating hydraulic parameters adopting U S Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS-2008) numerical model with the field observed data
- Adoption of suitable empirical relationships for estimating sediment transport
- Evolution of suitable discharge vs sediment transport charts for various slopes of river

HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The basic computational procedure is based on solving the one-dimensional energy equation using the Mannings' equation in conjunction with the contraction and expansion coefficients using a procedure similar to the standard step method. The steady flow water surface profiles computation can handle the subcritical, supercritical and mixed flow regimes. The in input to the model is Geometric data, flow data and boundary condition. The output consists of water surface level, velocity and Froude number. The Central Water Commission (CWC) of Government of India has flow observation data for Musiri site. The observation indicate that for a discharge of 575 m^3/s ,the water level at Musiri is 83.480m on 22-9-2012. Initially the cross section at Musiri was adopted for the numerical model studies using HECRAS. In the present context the HEC-RAS model runs were performed for the observed discharge of 575 cumecs and calibrated to result the water profile as (+)83.480m. The observed and computed water levels by HECRAS are in close agreement and the results are shown in Fig 5. The calibration fixes the value of constants in HECRAS model. The finalised model with calibrated constant has been adopted for further hydraulic computations.

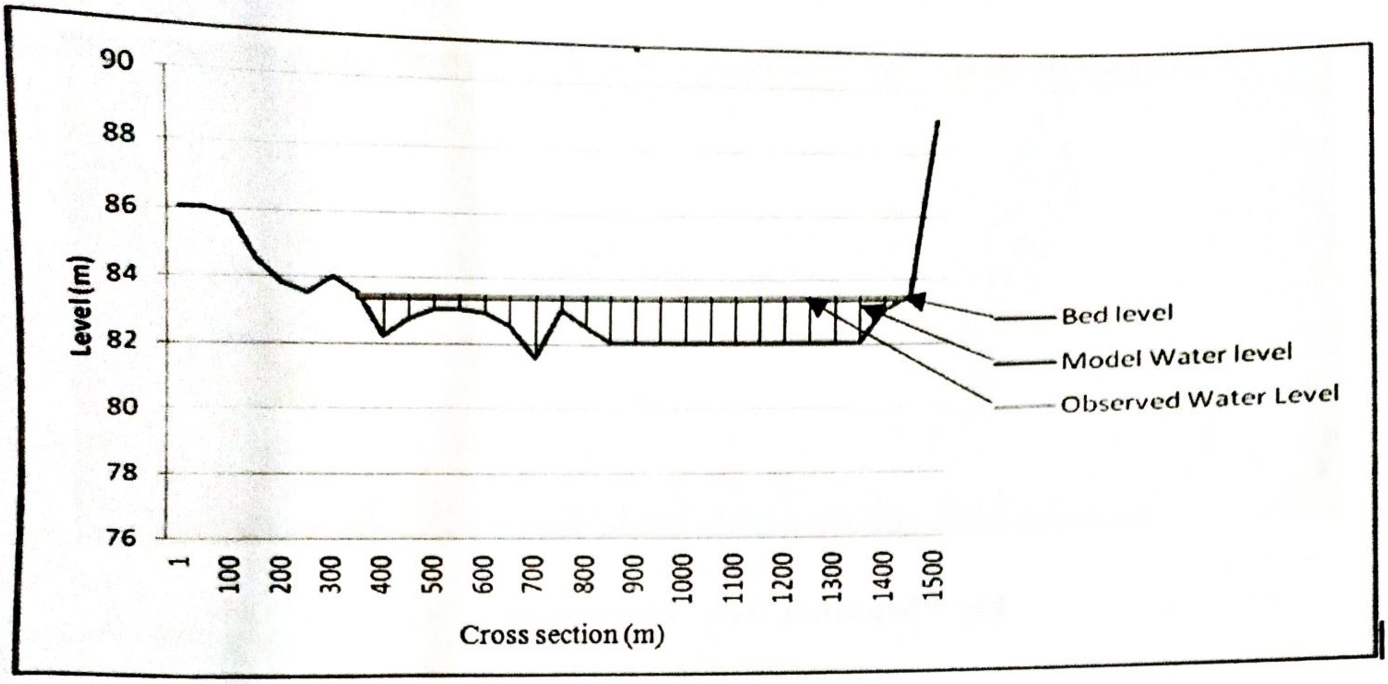

Fig 5. Comparison of predicted and observed water level.

4.0 FIELD MEASUREMENTS

The Water Resources Dept (WRD) of Public Works Department , under Tiruchy region, Government of Tamilnadu is engaged in sand quarry activities at various sites along Cauvery. One of such site is MPuthur (10°N80°E). The site is located downstream of Mayanur barrage and is shown in Figures 6. After the completion of sand mining project in the reach, three cross sections were selected and depth of sediment accumulation was monitored from August 2013 to June 2015 for a width of 500m. The river has undergone various flow values during this period. The average depth of sand formation in the above period along the river length of 330m was estimated as 0.76m. The monthly river flows from August 2013 to June 2015 are indicated in Figure 7.

Fig 6 Mputhur observation site

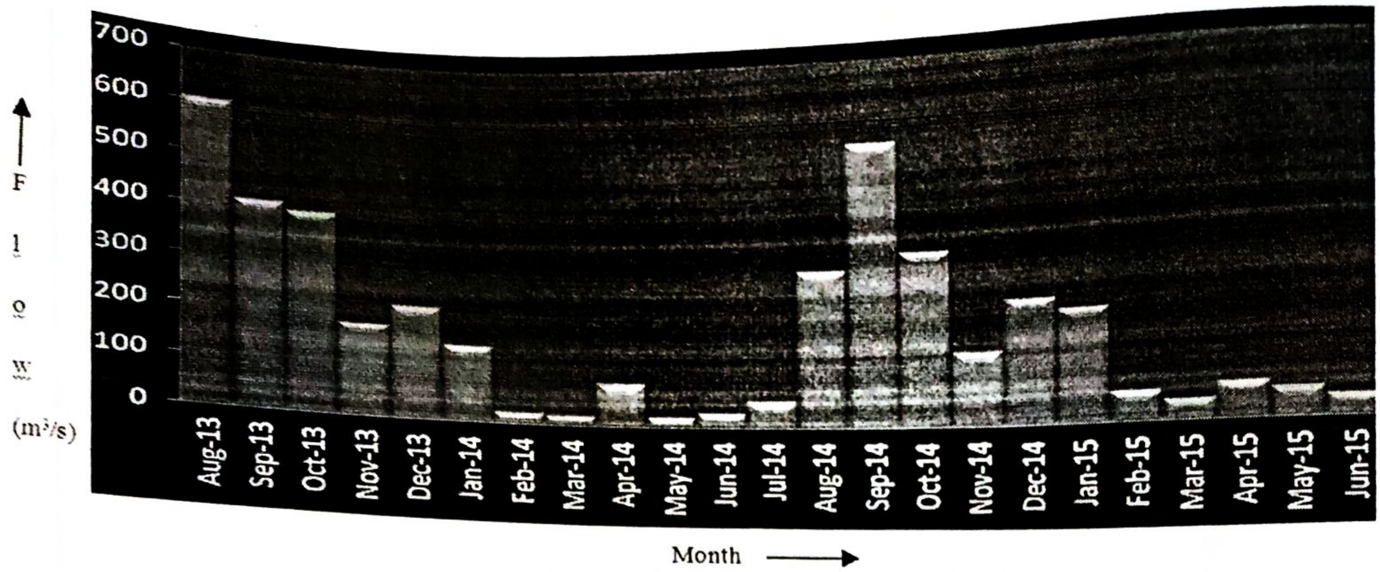

Fig 7 Mputhur flow observations

5.0 BED LOAD ESTIMATION

The transport rate of sediments in the bed load q_b is usually referred in units of weight per second per unit width (N/s/m). A very large number of empirical relations are available. Two main parameters used are bed Shear stress τ_o and critical shear stress τ_c. In alluvial channel the particles will start moving when bed shear stress exceeds critical shear stress. The most widely used expression is that of Meyer-Peter-and Muller (1948). This relates non dimensional parameter called shear stress parameter 'τ_*' with bed load function parameter ϕ_b. The effective size of sand particle is 0.4mm, Mass Density is (ρ_s) 1850Kg/m³. The bed **Shear** stress τ_o, **critical** shear stress τ_c and other parameters are as follows

$\tau_o = \gamma_w R S_o$

$\tau_c = \tau_o / (g(\rho_s - \rho_w) d)$

$\tau_* = (\gamma_w R S_o / (\gamma_s - \gamma_w) d) (N_s/N)$

$\phi_b = 8 (\tau_* - 0.047)^{3/2} = (q_b / (g d^3)^{1/2}) (1/((\gamma_s / \gamma_w) - 1)^{1/2})$ where

q_b = Bed load in N/s/m

d = mean sediment size / effective size (m)

ρ_s, ρ_w = Mass density of soil and water

γ_s = Unit weight of sediment particle

γ_w = Unit weight of water

N_s = Mannings Coeff for particle roughness = $(d^{1/6}/21.1)$

N = Mannings coeff for channel

R = Hydraulic mean radius

S_o = Longitudinal slope of channel

6.0 SEDIMENT ESTIMATION IN CAUVERY BY FIELD OBSERVATIONS

The river Cauvery will have flow for irrigation during south west monsoon from June. The sand mining activities commenced in the year 2004 by the government department. The flow data in Cauvery from the year 2004 to 2015 was collected and analysed. The monthly values for the periods are provided in Fig 8. The high values were observed during the period 2005-06 and 2007-08. Apart from these the flows during other years were nominal. In an irrigation year commencing from June and ending in May and the flow values were mainly observed during months of July to January and minimum flow was observed during the rest of time. The observations are furnished in Fig 8.

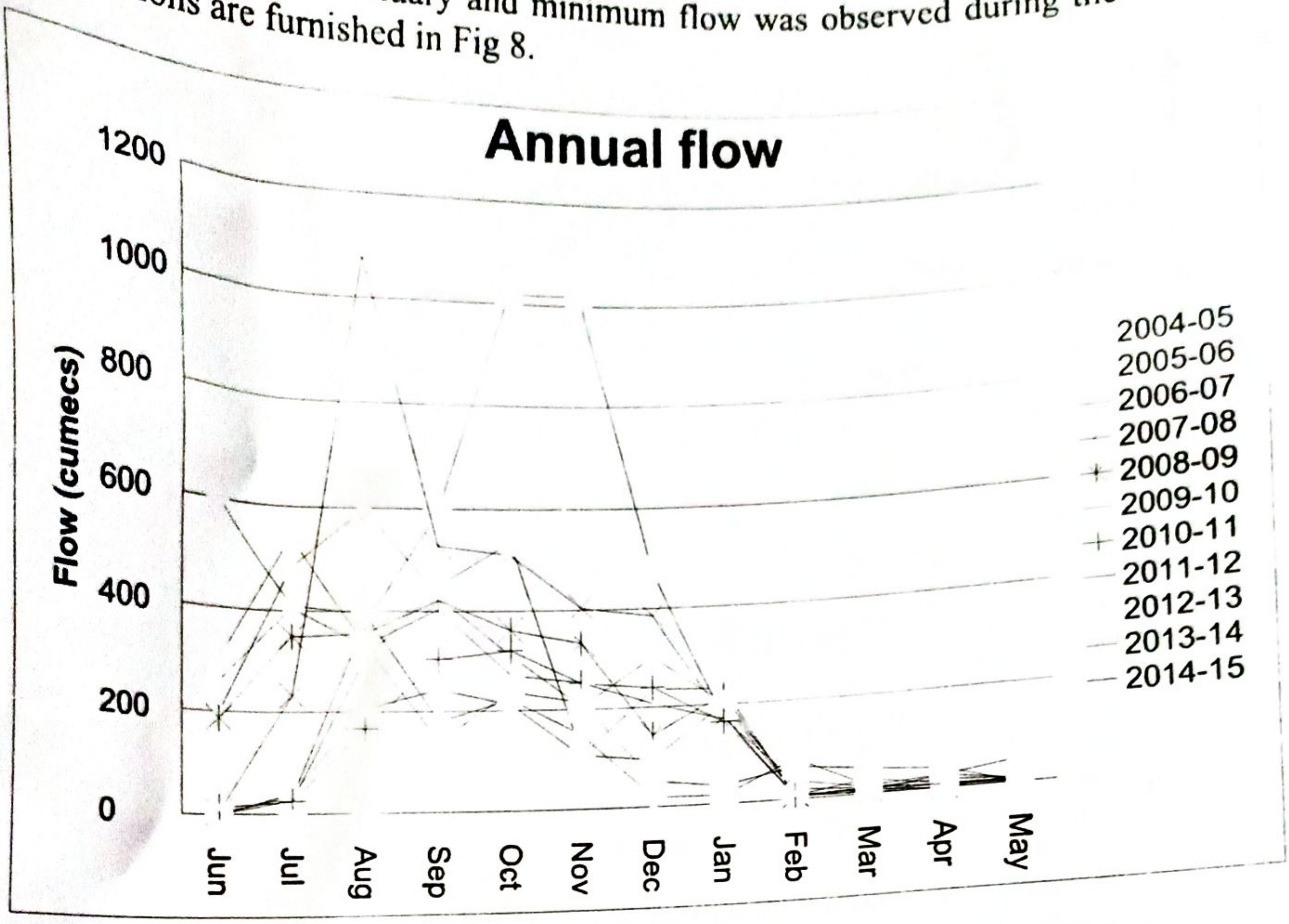

Fig 8 Flow in Cauvery River from 2004 to 2013

The analyses of the flow data indicates that river Cauvery flows throughout the year with values varying from a minimum to maximum value. Because of the flows there will be formation of sediment deposits along the bed. Based on the discharge values , the bed form will take place. Initially the bed load for different monthly discharges from 2013-2015 were assessed and compared with the the actually measured one at the cross section at M Puthur. The width and length of the observed site at Mputhur was 500m by 380m. The annual depth of formation assessed along the observed cross sections at Mputhur site was 0.61m .

7.0 THEORETICAL ESTIMATION OF BED LOAD

The monthly average flow data was initially adopted for theoretical estimation. Based on the average monthly flow data, the bed load sediment formations were estimated adopting the empirical relationship discussed. The average estimated depth of formation calculated corrosponding to the monthly discharge values and annual formation is estimated as 0.80m indicating close coincidence of estimated and oberved values. Hence the methodology was adopted to evolve a relationship between depth of sediment formation and monthly discharges.The sediment transport is given in terms of formation depth in cm for monthly flow (m^3/s) values. Least square fit of 2nd degree polynomial form is obtained for adoption in the field. The finalized expressions are presented in the form of charts in Fig 9. The charts are generated for the various commonly found effective size of sand in Cauvery River.

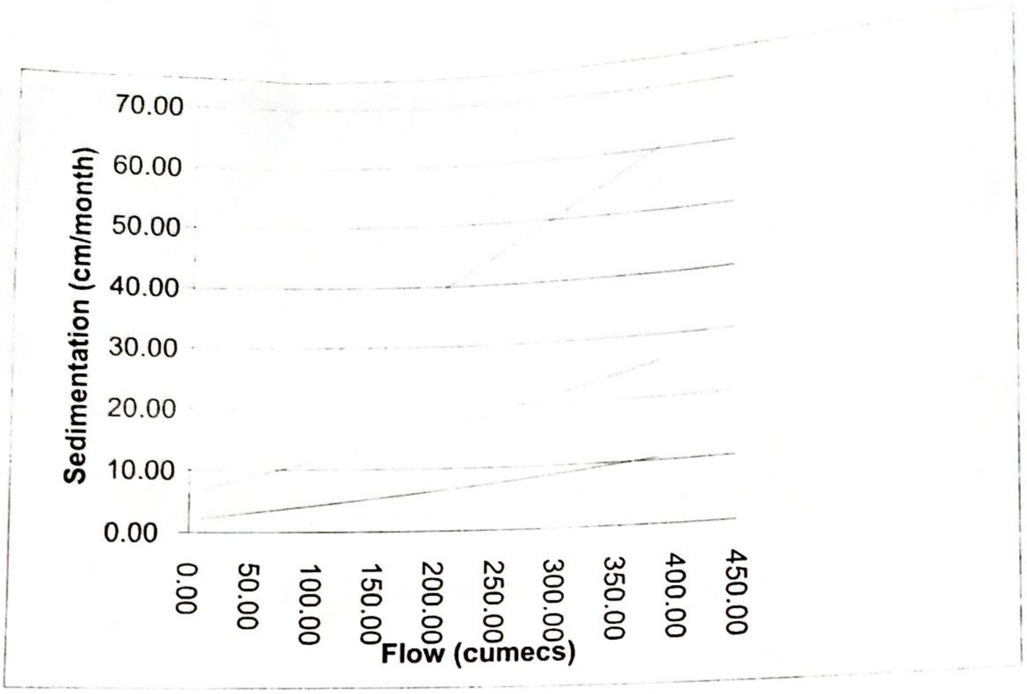

Fig 9 Flow vs Sediment

8.0 CONCLUSION

The detailed analyses of flow data and sediment bed load calculations were carried out for the stretch of river Cauvery. HECRAS one dimensional model was adopted for hydraulic computations. The initial estimation of sediment was calibrated based on the field observations of MPuthur data. The monthly analyses of sediment depth based on a cross width of 500m is adopted. The irrigation year is from June to May. Based on the field calibration, this approach of bed load estimation was applied for evaluating sediment formation. The monthly flow discharges from 2004 to 2015 was adopted. The studies indicate that considering the irrigation year from June to May, the most formation take place during the months from July to December. The sediment depth formations for each month are provided in the form of charts and equations for river Cauvery. These can be adapted for deciding the depth of sand mining

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Complexity Assessment of Modular Formwork Construction using Design Structure Matrix (DSM)

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Abstract

The construction project management is the most complex and dynamic activities. Project management techniques such as CPM, PERT techniques were developed for the effective planning, scheduling and controlling of the projects. Later simulation techniques such as SLAM, GASP, etc., were combined with the project management techniques to explore additional capabilities. However these networks based project management techniques suffers seriously on the factors like inadequate representation of the cyclic activities or repetitive task and computation of delay and lack in the progress of th e projects. Thus an intriguing technique which could represent the inter-dependency relationship of the activities so as to ease the planning, scheduling and controlling aspects of the project was demanded. One such technique is known as Dependency Structure Matrix (DSM), which was used extensively in this research. The DSM is a simple, compact and visual representation of a system or project in the form of a matrix. To reinforce the importance and applicability of DSM, it is used in the complexity assessment of modular formwork systems used in the building construction. By using prime phases such as partitioning, tearing, banding and clustering processes, the network is optimized.

Keywords: Critical Path Method, Design Structure Matrix (DSM) modular formwork, Scheduling.

1.0 INTRODUCTION

Formwork is a structure, usually temporary, used to contain poured concrete and to mould it to the required dimensions and support until it is able to support itself. Formwork supports its own weight along with the freshly poured concrete as well as the construction live loads. They have a significant impact on the cost time and quality of the project, their main objectives being quality, safety & economy.

The essential requirements of formwork are

- It should be strong enough to take the dead and live loads during construction.
- The joints in the formwork should be rigid so that the bulging, twisting, or sagging due to dead and live load is as small as possible. Excessive deformation may disfigure the surface of concrete.
- The construction lines in the formwork should be true and the surface plane so that the cost finishing the surface of concrete on removing the shuttering is the least.
- Formwork should be easily removable without damage to itself so that it could be used repeatedly

Traditional or conventional formworks and system or engineered formworks are the two types of formwork used in construction. As the conventional formworks could not account for the quality safety and economy aspects, system formworks are more beneficially used due to their increased speed of construction and lower life cycle cost.

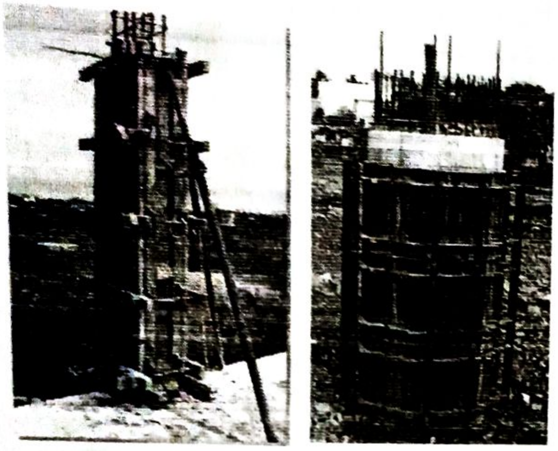


Fig. 1: Typical traditional formwork

1.1 Modular formwork

In order to provide solutions to the slow rate of construction, high level of wastage & poor safety aspects of conventional formwork systems, modular formworks precisely engineered with extensive speed and efficiency characteristics are designed. These formworks increase accuracy , minimize waste in construction and mostly enhance health and safety features built-in. In modular formwork system, all the elements of a building namely, load bearing walls, columns, beams, floor slabs, stairs, balconies etc. can be constructed with cast in place concrete. This results in a structure with good quality surface finish and accurate dimensional tolerances.

The modular nature of the formwork system allows easy fixing and removal of formwork and the construction can proceed speedily with very little deviation in dimensional tolerances. Further, the system is quite flexible and can be easily adapted for any variations in the layout. The adoption of modular formwork system using monolithic concrete construction has been found to be the most efficient alternatives. The stresses in both the concrete and steel are observed to be much lower even when horizontal forces due to wind or earthquake are taken into consideration.

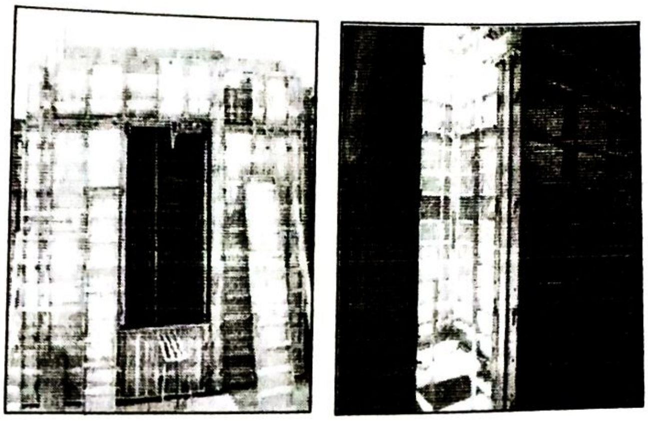


Fig. 2: Modular formwork

Modular formwork systems have the following advantages over conventional formwork systems

- More seismic resistance due to the box type of construction
- Increased durability due to complete concrete structure than conventional brick bat masonry.
- Lesser number of joints thereby reducing the leakages and enhancing the durability.
- Due to shear walls the walls are thin thus enabling higher carpet area.
- Integral and smooth finishing of wall and slab.
- Uniform quality of construction .
- Negligible maintenance
- Unsurpassed construction speed can be achieved due to light weight of forms paving way for faster completion.
- Lesser manual labour is required for carrying formworks.
- Simplified foundation design due to consistent load distribution.
- The natural density of concrete wall result in better sound transmission coefficient.

Modular formwork uses aluminum, high tensile steel, fibre glass or special plastics for different components which can be safely manhandled to achieve a practical formwork system. The components of the modular formwork systems are engineered to give tough and easy-to-handle solutions capable of dealing with both regular and irregular formwork areas. Minimizing the number of different components in a formwork system allows mobility and quick installation of the formwork. A wide range of lightweight modular formwork systems is available for the construction of most types of structure. They are suitable for any type of concrete frame construction.

2.0 DESIGN STRUCTURE MATRIX

Conventional tools like the critical path method (CPM) and program evaluation and review techniques (PERT) are not suitable for sequence analysis because they cannot model interdependent activities .In order to meet the growing demand for completing the projects quickly, one has to manage the information flow.

Design Structure Matrix (DSM) is a simple tool to perform both the analysis and the management of complex systems. It enables the user to model, visualize, and analyze the dependencies among the entities of any system and derive suggestions for the improvement or synthesis of a system. As a tool for system analysis, DSM provides a compact and clear representation of a complex system and a capture method for the interactions/ interdependencies/ interfaces between system elements..

Researchers have investigated the dependency structure matrix (DSM) as a tool to identify and manage information exchange between activities. Factors such as strength of dependency, sensitivity, and a few other factors have been used to quantify the information transfers among the activities for planning the sequence. Although extensive DSM research has been carried out in manufacturing and other disciplines, little work has been done in construction. Construction researchers in VTT (Technical Research Centre of Finland) have demonstrated through case studies that the DSM can be used for finding better sequences for building a design process. Similarly, at Loughborough University, researchers have developed a DSM-based methodology called the analytical design planning technique (ADePT) and have tested its applicability in building projects

	A	B	C	D	E
ELEMENT A	■		●		
ELEMENT B	●	■	●		
ELEMENT C		●	■		●
ELEMENT D		●		■	
ELEMENT E	●				■

Fig. 3 Representation of a Design Structure Matrix

The DSM is a square matrix in which the rows and columns are identically labeled and relationships or interactions between the elements in the rows and columns are identified by shading or marking of the appropriate cells in the matrix. An important feature of the matrix is the diagonal. The cells on the diagonal of the matrix represent the system elements and inputs enter the element either from the left or from above or below. In this way all inputs into an element in the matrix (a row) can be visualized as marked cells in that row. These inputs represent the outputs of the relevant elements in the columns. The diagonal cells generally have no value but the duration for each activity can be included. The activities have to be read along the columns as "gives information to" and along the rows as "needs information from." The marks above the diagonal are called feedback marks and the marks below the diagonal are called feed forward. If any mark lies above the diagonal, it implies that an assumption has to be made to execute the corresponding sequence

2.1 Types of activity relationships

There are three basic relationship amongst system elements: parallel (or concurrent), sequential (or dependent) and coupled (or interdependent)

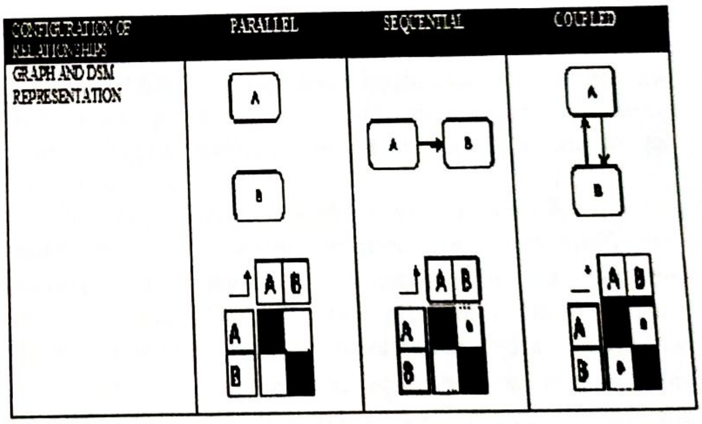


Fig. 4 Types of relationships

2.2 DSM Process

The DSM is analyzed for optimization using prime phases such as partitioning, tearing, banding and clustering processes.

2.2.1 Sequencing/partitioning

Sequencing is the reordering of the DSM rows and columns such that the new DSM arrangement does not contain any feedback marks, thus transforming the DSM into an upper triangular form. However for complex engineering systems, it is highly unlikely that simple row and column manipulation will result in an upper triangular form. In such cases the objective changes from eliminating the feedback marks to moving them as close as possible to the diagonal. The process of rearranging the order of activities in such a way that there is movement of dependency relationships either below the diagonal or close to the diagonal and the formation of blocks is called partitioning

2.2.2 Tearing

Tearing is the process of choosing the set of feedback marks that, if removed from the matrix will render the matrix upper-triangular. The marks that we remove from the matrix are called "tears". Tearing a DSM is intended to reduce the number of feedback loops.

2.2.3 Banding

Banding is the addition of alternating light and dark bands to a DSM to show independent (i.e. parallel or concurrent) activities. Banding a DSM identifies sets of independent elements and shows the adequate algorithms.

2.2.4 Clustering

The main objective of this phase is finding subsets of DSM elements that are mutually exclusive or minimally interacting subsets clusters as groups of elements that are interconnected among them to an important extent while being little connected. This process is referred to as Clustering. Clustering absorbs most of the interactions internally and the interactions or links between separate clusters are eliminated or at least minimized.

3.0 COMPLEXITY ASSESSMENT

The general view of the construction process is that it is an ordered, linear phenomenon, which can be organized, planned and managed top down. The frequent failures to complete construction projects on budget and schedule give rise to thinking that the process maybe not is as ordered and predictable in its nature as it may look. A closer examination reveals that construction is indeed a complex, nonlinear, dynamic phenomenon which often exists on the edge of chaos.

Construction activities are highly dynamic and complex in nature. Unlike other industrialized projects, the construction projects are bound by large interdependent activities and uncertainty in the time and hence results in decreased profitability. Some project management techniques such as CPM, PERT, GERT, Q-GERT has been developed and used for the effective utilization of the project however they are probabilistic and rather not reliable. Therefore Managing complex systems is therefore a core competency to successfully complete any construction project on time.

4.0 APPLICATION OF DSM IN COMPLEXITY ASSESSMENT

Traditional project management methodologies including PERT and CPM are useful tools for handling some of the problems associated with construction projects. For example, given a list of project tasks with corresponding estimates of completion times and precedence relationships, the critical path listing those tasks crucial in determining the overall project completion time can be easily determined. However, these methodologies fail to take into account many of the complicating factors inherent in managing construction projects. GERT (Graphical Evaluation and Review Technique), a transform based method of describing networks algebraically, overcomes some of the limitations of PERT analysis..

The key factors confounding successful project management of construction processes were ineffective measures of scheduling, resource utilization and the iterative nature of construction processes. Over the past decade, several researchers have developed an alternative project management tool that explicitly takes into account the iterative nature of construction projects; this is the Design Structure Matrix (DSM) approach. While DSM methodologies encompass the iterative nature of design projects, exact analysis of the computational difficulty of problems of this nature has remained relatively unexplored.

4.1 Application of DSM in Complexity Assessment of Modular formworks

Estimates indicate that 30 to 70 percent of cast-in-place concrete cost is attributable to the total cost of the formwork. This wide percentage range is partially due to factors that are not well understood with regard to their influence on productivity. Therefore, there is a need to analyze the various complex factors influencing formworks in construction projects. Scheduling of concrete formwork systems is one of the important factors to be considered. Since there is only a minimal research being undertaken in this area, there is a need for detailed analysis for scheduling concrete formwork systems taking into consideration the interdependencies between project activities. This paper focusses on assessing the complexity factors related to modular formwork systems using DSM and resulting in improved scheduling, resource utilization and minimizing iterations or repetitions that takes place among formwork activities of a construction project.

4.1.1 Implementing methodology of DSM in Modular formworks

4.1.1.1 Original DSM

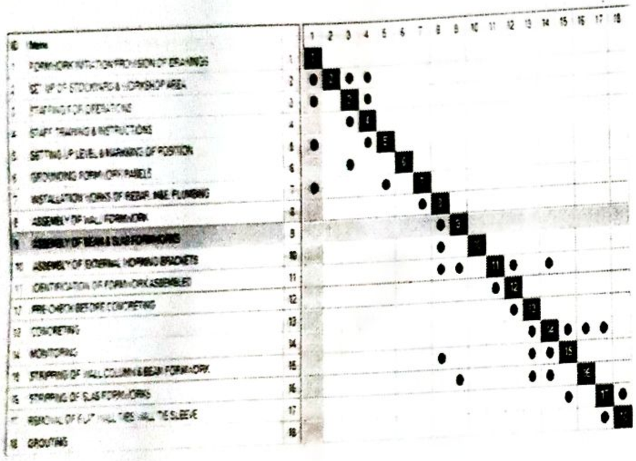


Fig.5: Original DSM

4.1.1.2 Partitioned DSM

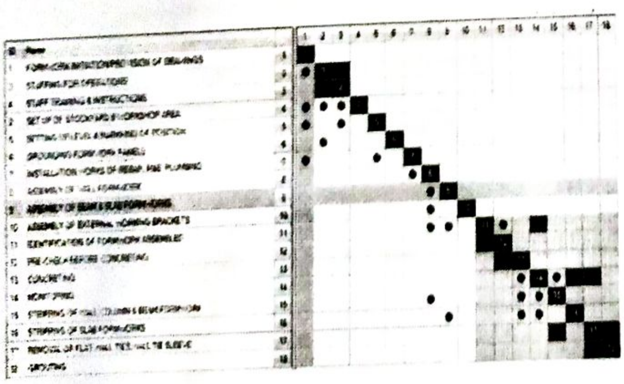
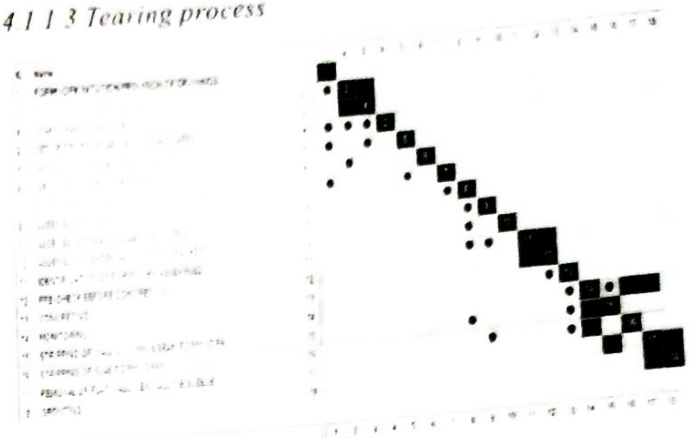
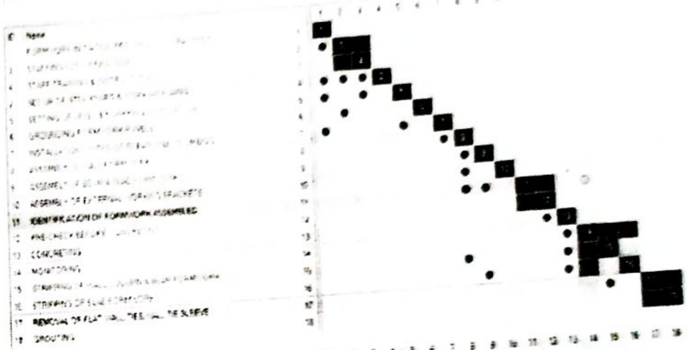
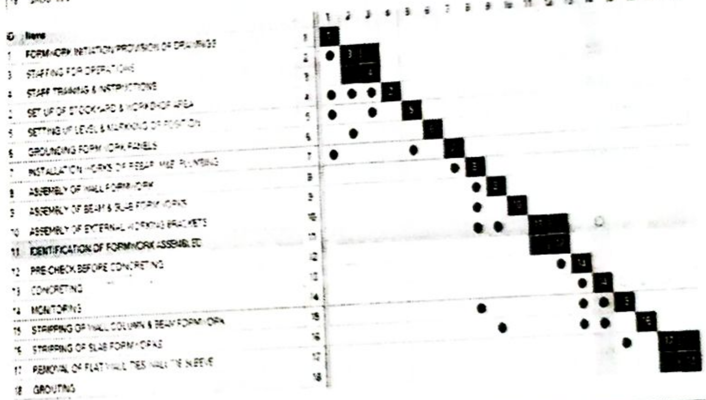


Fig.6: Partitioned DSM

4.1.1.3 Tearing process







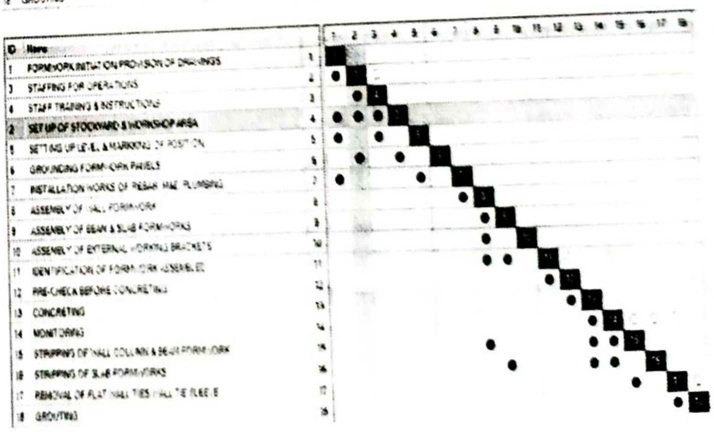


Fig.7 Tearing process (contd.)

4.1.1.4 Repartitioned Matrix

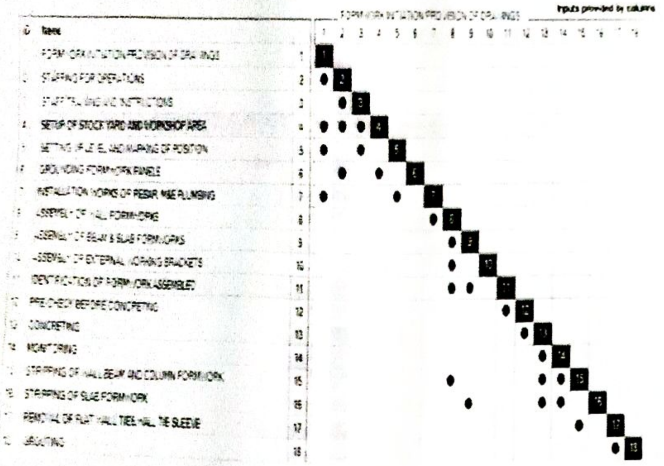


Fig.8 Repartitioned Matrix

4.1.1.5 Optimised Network

	A	B	C	D	E	F
1	1	1	FORMWORK INITIATION/PROVISION OF DRAWINGS	1		7
2	2	3	STAFFING FOR OPERATIONS	1	1	7
3	3	4	STAFF TRAINING & INSTRUCTIONS	1	2	14
4	4	2	SET UP OF STOCKYARD & WORKSHOP AREA	1	1,2,3	21
5	5	5	SETTING UP LEVEL & MARKKING OF POSITION	1	3,1	4
6	6	6	GROUNDING FORMWORK PANELS	1	2,4	2
7	7	7	INSTALLATION WORKS OF REBAR, M&E, PLUMBING	1	5,1	10
8	8	8	ASSEMBLY OF WALL FORMWORK	1	7	4
9	9	9	ASSEMBLY OF BEAM & SLAB FORMWORKS	1	8	6
10	10	10	ASSEMBLY OF EXTERNAL WORKING BRACKETS	1	8	3
11	11	11	IDENTIFICATION OF FORMWORK ASSEMBLED	1	9,8	2
12	12	12	PRE-CHECK BEFORE CONCRETING	1	11	1
13	13	13	CONCRETING	1	12	1
14	14	14	MONITORING	1	13	1
15	15	15	STRIPPING OF WALL,COLUMN & BEAM FORMWORK	1	8,13,14	3
16	16	16	STRIPPING OF SLAB FORMWORKS	1	9,13,14	2
17	17	17	REMOVAL OF FLAT WALL TIES,WALL TIE SLEEVE	1	15	1
18	18	18	GROUTING	1	17	1

Fig.9 Exported CSV file from DSM

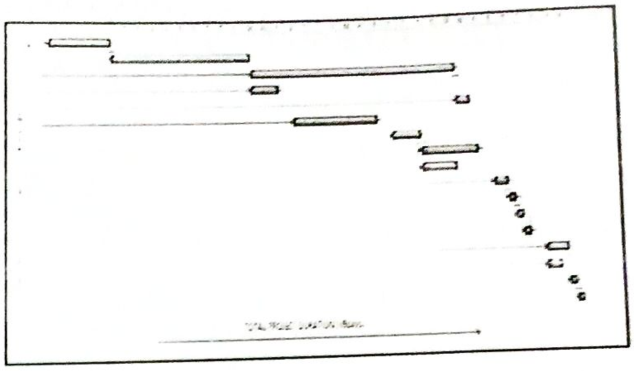


Fig.10 Gantt Chart for the repartitioned matrix

5.0 CONCLUSION

- DSM is useful for planning the activity sequences and managing information exchanges among activities.
- DSM provides an easy method to understand the dependencies among the various activities involved in the project.
- It helps identify the sequence of activities which takes the least amount of time to finish a project primarily of interdisciplinary nature.
- The DSM-based solution procedure for project planning involving the formation of activity DSM, partitioning, tearing, clustering has been discussed and procedure is applied for planning and analyzing various complexity factors involved in the modular formwork activities

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