Human and Equipment effort involvement in sub structure of bridge construction project

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***Abstract*: Bridge Construction is the most powerful industry in infrastructure sector in India. It consists of fly over, ROB, cable stayed bridge, cantilever bridge as well as suspension bridge. Without contribution of human and equipment effort bridge infrastructure is impossible. To find out the involvement of human and equipment in sub structure of bridge were worked on such a concept for that identified activities for various components of sub structure in addition circulate a questionnaire survey with scalable parameter and analyzed data with the help of descriptive analysis as well as SPSS software. Interestingly, found such a results which comprise 68.64% human effort and 54.84% equipment effort. To validate such a data also carried out case study of the bridge project and landed right on our previous results.**

***Index Terms*: Human effort, Equipment effort, Involvement, Bridge sector, Sub Structure, Journals**

I. INTRODUCTION

Infrastructure is necessary to empower modern societies Products, energy, continuous flow of information and many governments have invested large sums of money in principle, infrastructure projects and plans contribute to the social and economic development and prosperity of your country. To accomplish USD 5 trillion GDP by financial year 2025(budget 2022), India needs to spend about USD 1.4 trillion over this period on infrastructure, as per the Economic Survey. During monetary years 2008-17, India siphoned in regarding USD 1.1 trillion on Infrastructure (The Economic times, 2022). Notwithstanding, the test is to move forward foundation venture considerably, the Economic Survey 2021-22 said.

Working in India refers to employment in the Indian economy. Equipment and labor play a very important role in completing any project. Equipment and labor are the basic resources of any construction project. Without them it would be impossible to complete the construction work. In 2020, there were around 501 million workers in India, among them 14.17% are construction Labor which are like to be a 74 million (Wikipedia, 2020). The current scenario is that there is a huge shortage of labor. The reasons behind the shortage of labor are low wages, non-payment of timely wages, weather conditions, due to festival season (Holi), contractor's attitude towards labor, etc. Which leads to many problems, such as lake of time, overhead charges, financial crisis, project cost, expenditure of liquidity damage, etc.

Whether a construction contract is unit price, lump sum, or cost-plus; whether the construction project is to be linear or fast-track the cost of construction is a major factor in all projects. The major factors that impact construction costs are materials, labor, equipment, overhead, and profit. The cost of equipment for civil engineering construction projects can range from 25 to 40% of the total project cost. There is a need to think about the fact that India's people is not more aware of technology. Attempts like technology fairs are often made to become technology savvy. To complete the project on time, could be take some steps to complete it within the budget and to avoid additional costs, such as increasing the use of machinery and completing the work on time which is advantageous. Moving forward, if there are increase the use of machines in bridge construction, many problems can be solved, such as completing projects on time, saving extra cost.

II. NEED FOR THE STUDY

In this 21st century, the world is moving towards infrastructure development and in this sense, for that should be improve our growth and work on the challenges ahead. With the help of this, can see the problem to some extent by looking at us. It will increase revenue, increase efficiency, complete tasks on time and more. It would be seems such a benefits of it.

III. OBJECTIVES

The scope of this study includes analysis and comparison of human effort and equipment effort in fly over bridge construction projects. The targets will accompanying by various methods like Time & Monitoring, VSM (value stream method), Cost of activity and thorough questionnaire survey were set for this review:

1. To evaluate level of involvement of human effort and equipment effort for sub structure of bridge construction.
2. To improve productivity of work for bridge construction.

IV. LITERATURE REVIEW

Content of literature

(Gouett M. C., 2011) In Ontario Canada, 2011 Gouett, Michael C., et al.did study on activity analysis for direct work rate improvement in construction. They worked on activity analysis process in construction industry. For that they did a six case Study to verify the feasibility of the activity analysis process. Further data collected from two major construction form on their 20 projects

data collected and analysis to statically validate the hypothesis. In conclusion that shown action analysis as continuous performance improvement process. It feasible and when contribution applied for construction site, can significantly improve direct work rate.

(Pradhananga, 2012) In Atlanta USA 2012 Nisha Pradhnanga Did a study on automatics spatio-temporal analysis of construction site equipment operations using GPS data. She worked on a technology and algorithms that has the potential in aiding the automated assessment of construction equipment operation. For that she enabled low-cost GPS device by which she get continuously location and action of the equipment. Further, she defined the data analyses methods and software interface to analyse several important equipment parameter towards achieving the goal. In conclusion she give results from field experiment which is shows that developed technology is able to identify and track equipment activities this study helps construction project manager in making better decision, to plan, manage and control equipment related work tasks on construction site.

(Shahtaheri, 2012) In Canada 2012 maryam shahferi did a study on setting target rate for construction activity analysis category. He worked on project cost and improvement productivity for that he defined target price by which he able to set expectations with respect to the productivity to be achieved in each cycle. He developed a mathematical model called ANFIS for setting the desired level of activities. The development model trained based on 65 data points and that model found to be easy to appropriate for all of the factors considered. he also define three other method by the help of data point from the various project sites in the conclusion the companies now have appropriate methods and initial data to establish the target data.

(Hickson, 2014) In West Indies 2014, B.G, Hickson & L.A Ellis did study on factor affecting construction labour productivity in Trinidad and Tobago. For that they were identified and predefined factors and divided into a category. They were used RII to give the ranking of the factor and they top 10 factors which are affected labour productivity in Trinidad & Tobago.

(M. Waris, June-2014) In Malasiya, 2014 M.Waris,Mohd.Shahir liew,Mohd.Faris Khamidi and Arazi Idras Were did study on criteria for the selection of suitable onside construction equipment. To determine the aim of the research they did questionnaire survey among the classified group of Malaysia contractors to information regarding the Sustainable selection of on-site equipment. They were used RII Analysis data. They derive the six factor compact analysis. The principle picture of performance life cycle cost, System capacity, Operational convince, environmental impact and benefits.

(Bao, 2016) In Urbana USA 2016 Ruxico bao, mohanmad amin sadeghi and mani golparvar fard did a study on characterizing construction equipment activity in long video sequences of earth moving operation via kinematics features. They presented a faster and scalable method for activity analysis of construction equipment involved in earth moving operations. From highly verifying long sequence video by fixed camera, they presented end to end automated method to recognize the equipment activities by simultaneously detecting and tracking features. Their experimental Results show that the method is capable of activity recognize with accuracy of 88.91% with computational time less than one to one ratio for each video length.

(Gurmu, 2017) In Australia 2017 Argaw tarekegn and agibade ayodegi aibiyu did a study on construction equipment management practice for improving labour productivity in multi-storey building construction project. They worked on to identify the construction equipment management practises that have the potential to improve productivity in multi-storey building project. For that defined baseline productivity factor when the level of implementation of equipment management practises. Further, they did questionnaire survey based on the factors and analysed the data. They said that construction equipment maintenance, plan and productivity analysed are most important practice for productivity of the construction. They suggested their study to contractor for improving the equipment management practice.

(Manikandan, 2018) In India 2018 prof. Manikandan, M., M. Adhiyaman, and K. C. Pazhani did study on study and analysis of construction equipment management used in construction projects for improving productivity. They work on different factors of machine management for that they collected data from equipment rental companies construction companies and multiple construction project they used the relative important index (RII).Top five significant factor identified where frequently equipment break down, maintenance of equipment ,insufficient number of equipment, performance and efficiency of equipment and adequate modern equipment system.

(Desai, September- 2019) In Maharashtra 2019, Prof. Pradip A Desai and Satujeet B Patil Study on labour productivity measurement for pre cast flyover bridge construction project. They find out the critical factor those are affected on labour productivity with the help of questionnaire survey. And those factors were observed bywork study method. The activities of productivities is finished by employing a time and motion study methodology and identified the high most issue that project timeline & Value.

(Hernandez, 2019) In CA,USA, Hernandez, Carlos, et al. did study on development and compare deep learning algorithm for construction equipment activity recognition in a different level of details the collected data in non-controlled environment from real-world activities they studied baseline CNNND conversion LSTM. Validation accuracy of deep concern LSTM achieve a 77.1% in a six class identification task.

V. DATA COLLECTION

To achieve the objective of research for human and equipment effort identify it was decided to do a data collection with intention of identify the human and equipment effort involved in sub structure of a bridge project.

Research Methodology

The The research methodology bifurcated in two stages. The first stage included a literature exploration and interviews. The literature review was explored through the source of research journal, Books, Article in a periodical and internet. To sum of everything that has can stated so far of this stage that is got by questionnaire survey method and should have to do data collection. Which involved various questions based on the bridge components. The next phase is to carry out the pilot survey of 3 experts in the bridge construction. To scrutinize as well as validation of the questionnaire data.

Questionnaire design

The questionnaire survey is being implemented to define the view of targeted people along the lines of contractors, clients associated with bridge construction. The Questionnaire form has distributed to project managers, Engineers and supervisors who are associated and expert with bridge construction.

The questionnaire form comprises three part to achieve the objective of the research.

1. Personal details of respondents likes designation, education, experience, project name & type etc.
2. Brief explanation how to fill the form as per the effort involvement in percentage range with sample and announcement off academy purpose only.
3. Enlisted the all section's activities of sub structure for bridge accordingly in which human and equipment effort involved.

Data Validation

To ensure the significant and complete reaction to the survey, an interview was taken with the expert to explain the aim of the research and acquire information on the design of the questionnaire. The questionnaire with all activities involved in sub structure of bridge construction who has connection with human and equipment effort were discussed and get the guidance require to add more activities or changes further need. The experienced and knowledgeable expert also test validity of the content. They were checked and validated the data of the questionnaire in term of the fulfilled the requirement, Language, Content and suggested the changes if required. As a result, they remarks regarding adjustment of the content and questionnaire which were taken into consideration.

Expert Remarks

Table 1 expert remarks

Sr.No.	Expert Details	Comments
1	Mr.Vaibhav Patel Prjrct Manager at Ajit Construction Co. Experience : 10 years	- Content is good - Suggested to add an activity
2	Mr. Sandip Patel Project manager At Prisha infracon Experience : 12 years	- language correction - overall good
3	Mr. Ruchit Patel Owner of Nohan Buildcon Experience : 12 years	- Proposed component to add - form content good

Sample Size

The term Sample size is important at research work in terms of to get the adequate amount of the sample. The targeted people for this survey are experienced project manager, Engineers and Supervisors. The formula for the representative Population statistical sample is given below:

$$SS = \frac{Z^2 * P * (1 - P)}{C^2}$$

Where:

Z = statistic value for the confidence level (e.g. 1.96 for 95% confidence level) P = percentage picking a choice, expressed as decimal (0.5 used for sample size needed)

C = confidence interval, expressed as decimal (e.g. 0.05 = ±5)

SS = 385

Further, it seemed redundant to sample 385 times for targeted populations less than the sample size. For this reason, a finite population correction factor was applied,

$$New\ SS = \frac{SS}{1 + \frac{SS - 1}{Pop}}$$

Where:

Pop = Population (100)

$$\boxed{\textbf{\textit{New Sample Size}} : \mathbf{80}}$$

Respondent summary

In respondents summary there are 43% respondents has less than 5 year experience, 40% respondents who have 5+ experience,14% respondents have 10+ experience and 4% respondents have 15+ experience.

VI. DATA ANALYSIS

The process of organizing, examining, clearing and get the outcome of the gathered data is called data analysis. It's is central part of the research work for separating and get the summarized data. There are various Methods to analysis data which is depended on type of the data and which kind of outcomes you want.

In this case there are using descriptive analysis method to measure the frequency and central tendency of the data. To analysis the collocated data SPSS Statistics software will be used, which is a statistics analysis software.

Reliability test

Reliability test is used for measuring internal consistency of the data. The reliability test is done by using Cronbach's Alpha in SPSS statistics software.

Cronbach's Alpha: It's Introduce by Lee Cronbach in 1951 (Statistic How to, 2017).which is reliable on survey along the line of Likert scale.

Cronbach's Alpha Formula

The formula for Cronbach's Alpha is:

$$\alpha = \frac{N \cdot \mathrm{C}}{\upsilon + (N-1) \cdot \mathrm{C}}$$

Where:

N = The Number of items

C = Average covariance between item-pairs

υ = Average variance

The concept about the formula is good to know for knowledge but in actuality you won't have to work it. With the help of SPSS statistics software Alpha is calculated effortlessly.

Table 2 case processing summary

Case Processing Summary

		N	%
Cases	Valid	80	100.0
	Excluded[a]	0	.0
	Total	80	100.0

a. List wise deletion based on all variables in the procedure.

Table 3 Reliability statistics

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.895	0.880	53

After the calculation of reliability statistics in SPSS, got the value of the Cronbach's alpha which is,

Cronbach's Alpha = O.895 ≥ 0.7, Hence it has great reliability.

Descriptive analysis

Descriptive analysis is a statistical technique used for various data analyses that help to visualize or summarize and describe the data points in a concise and productive way so that you can find patterns that fit all the circumstances of the data. The descriptive analysis method is especially useful in the analysis of statistical data.

Here frequency measurement and centralization of the collected data were used according to data collection method for data analysis. There should be enter numerical values to satisfy the need for analysis so that SPSS software can work with statistics. Here below the **figure 1** shows that,

Measurement of frequency

When using descriptive analysis, it is important to know how often a particular reaction can occur. The main purpose of frequency measurement is to make it look like a calculation or a percentage.

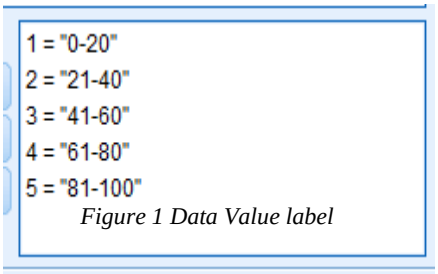
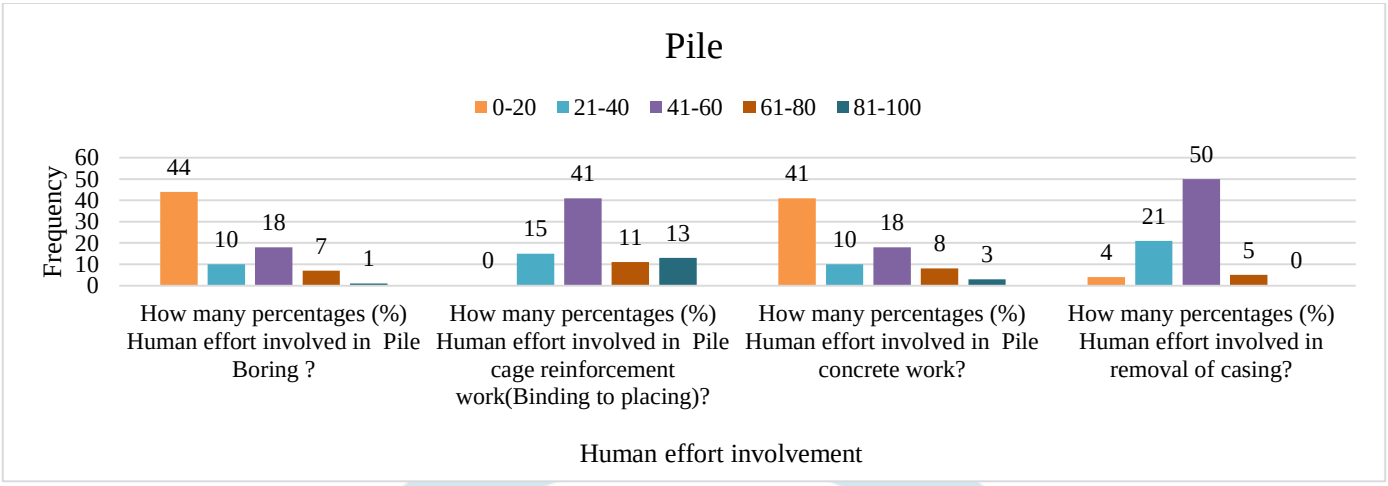


Figure 1 Data Value label

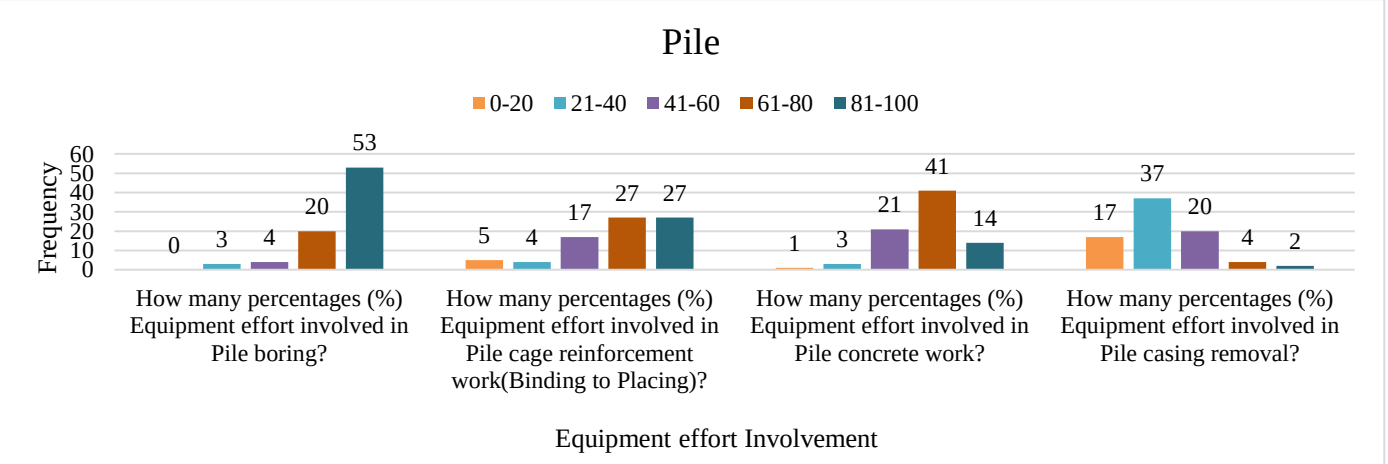
In our collection there are 80 respondents who have given different opinions on same question, here is a graph of the frequencies measured on different components for sub structure of bridge.

As presents below **Graph 1** for pile component has a four activities in which pile boring & concrete work got higher frequency in terms of less human effort,



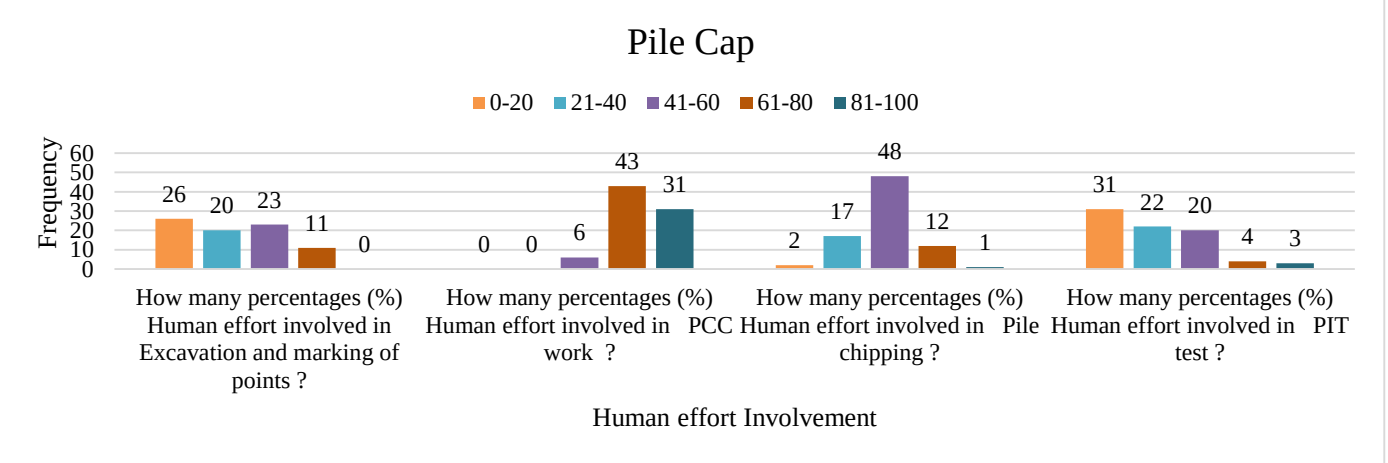
Graph 1 Pile Human Effort Frequency

As shown below **Graph 2** there are for activities connected with pile among them pile boring & concrete work has a greater frequency given by the respondents in terms of greater Equipment effort.



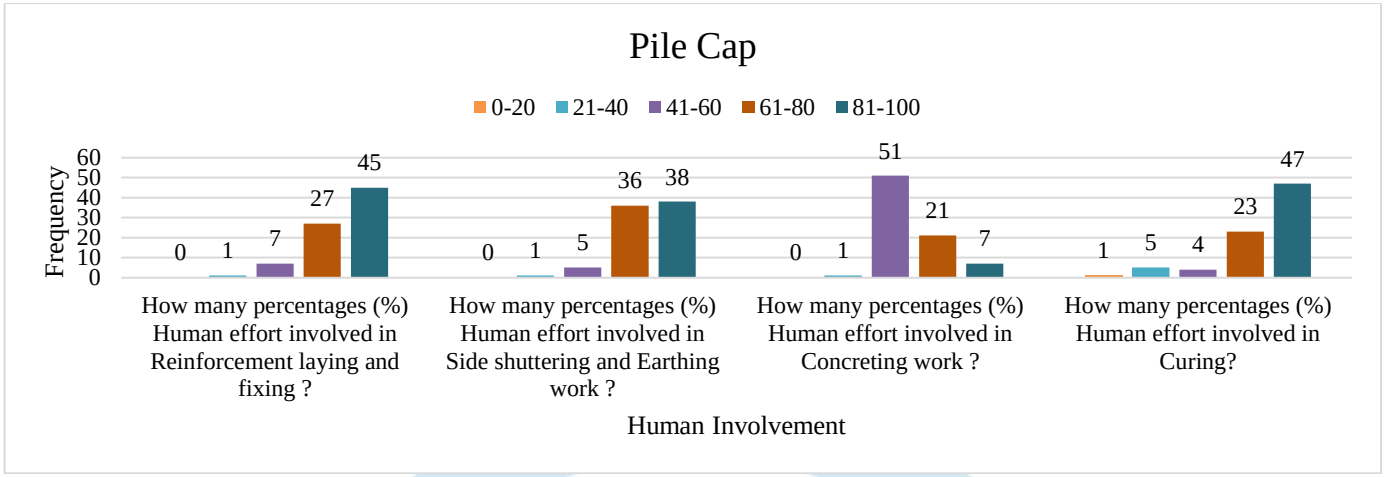
Graph 2 Pile Equipment Effort frequency

As shown below **Graph 3** Pile cap has various activities in which all activities which are rated by respondents have Pile chipping and PCC work got higher frequency.



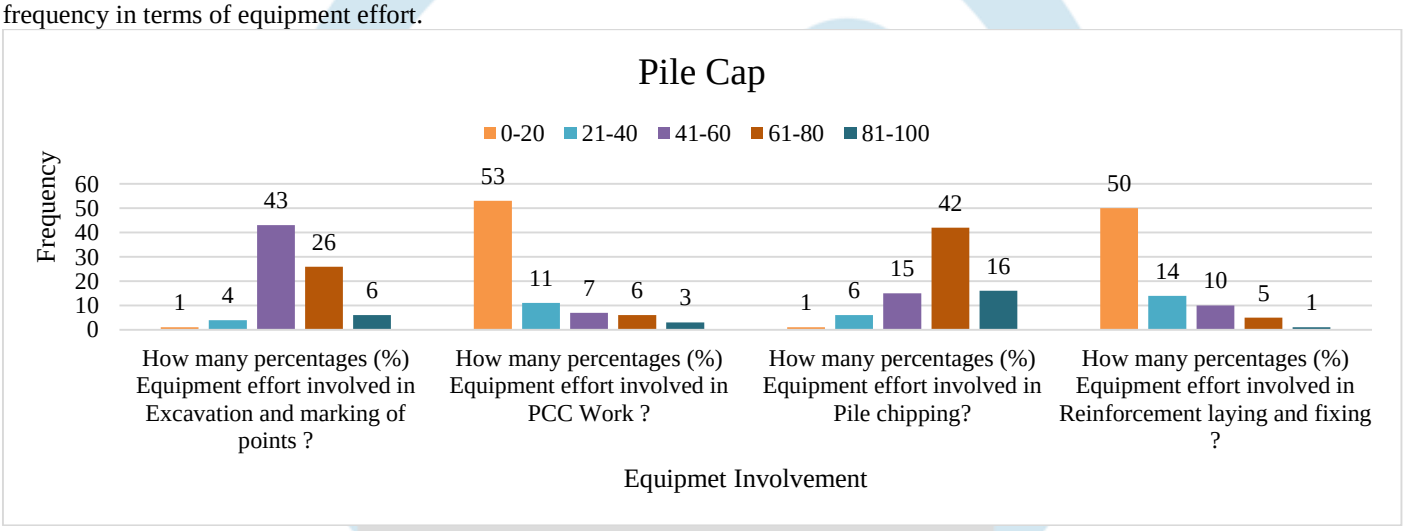
Graph 3 Pile Cap Human effort frequency

As per shown below **Graph 4** there are four activities in Pile cap segment among them reinforcement laying and concrete work has a higher frequency in terms of Human effort frequency.



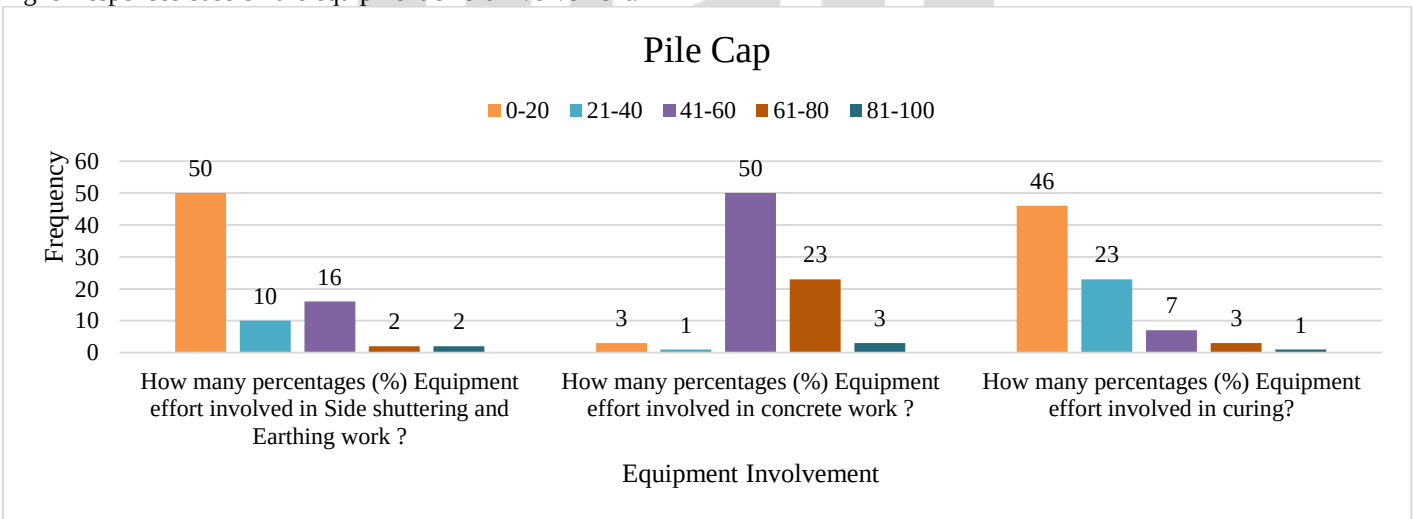
Graph 4 Pile Cap Human effort Frequency

As shown below **Graph 5** Pile cap component has various activities in which reinforcement work and pcc works has a higher frequency in terms of equipment effort.



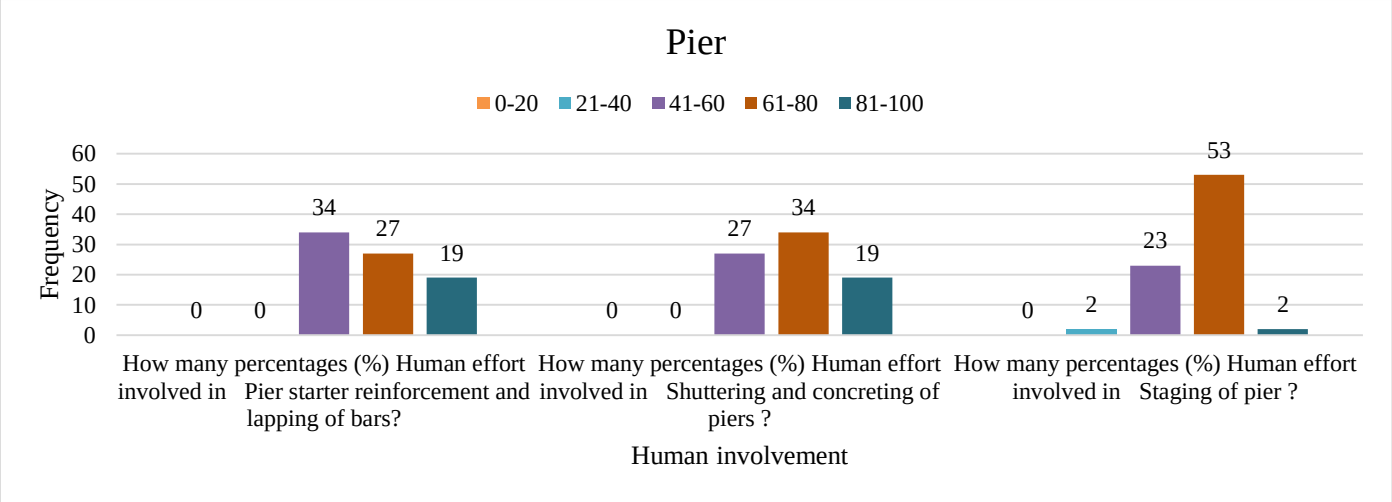
Graph 5 Pile Cap Equipment effort frequency

As shown below **Graph 6** which have a several activities of Pile cap segment in which respondents given earthing and curing got higher responses base on the equipment effort involvement.



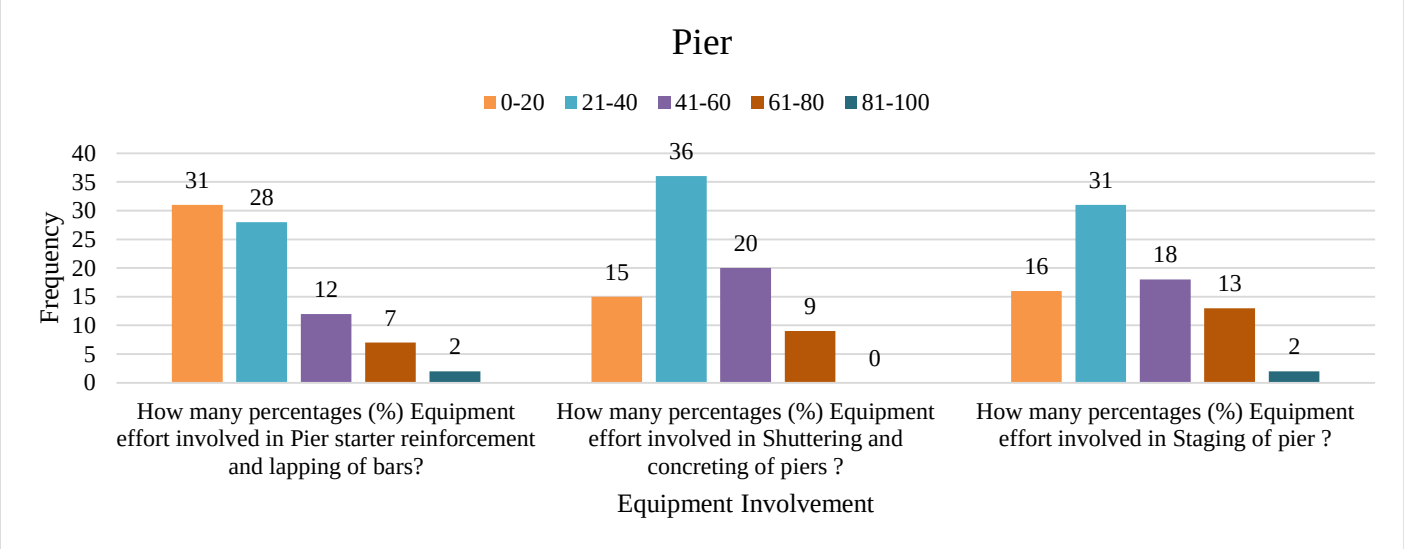
Graph 6 Pile Cap Equipment effort frequency

As per **Graph 7** shown below has a frequency of Pier activities in which respondents given a rating based on human effort involved in Pier.



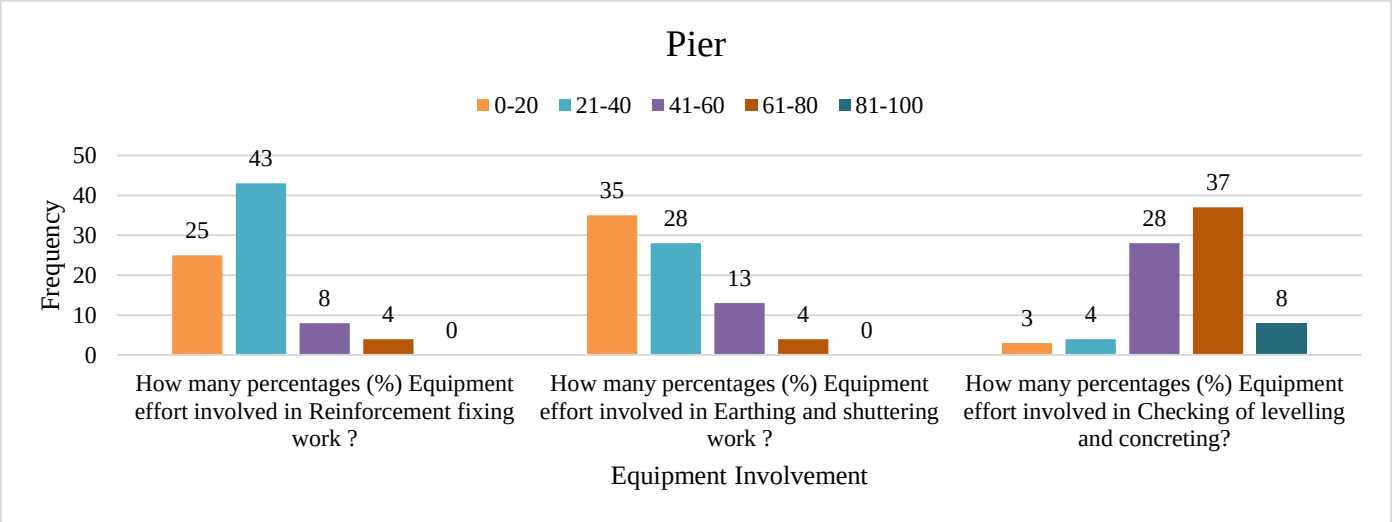
Graph 7 Pier Human effort frequency

As per **Graph 8** shows all activities have got a similar frequency among all activities of pier.



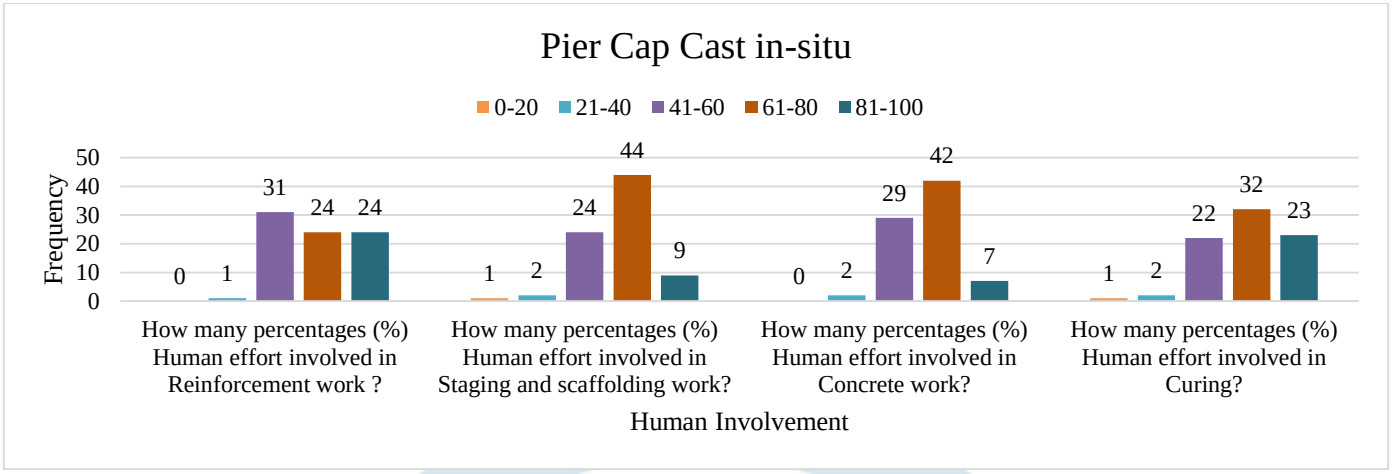
Graph 8 Pier Equipment effort frequency

The **Graph 9** shown below has a frequency of the Pier activities among them respondents given responses based on human effort involvement, reinforcement have a higher frequency of equipment involvement.



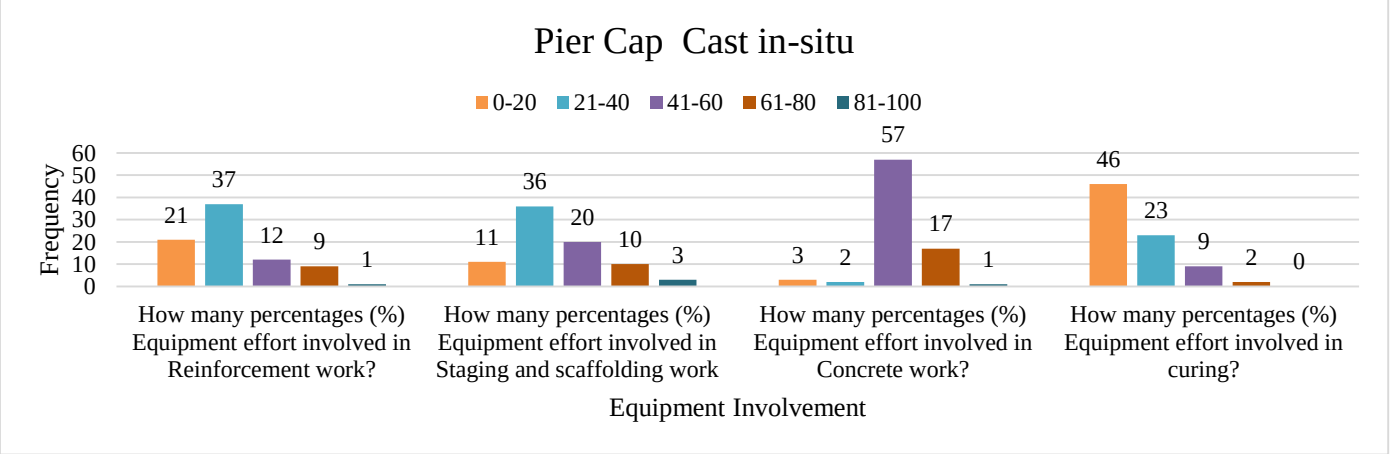
Graph 9 Pier Equipment effort frequency

As per **Graph 10** shown the frequency of human effort involved in Pier cap cast in-situ activities there are concrete work, scaffolding work got a higher frequency.



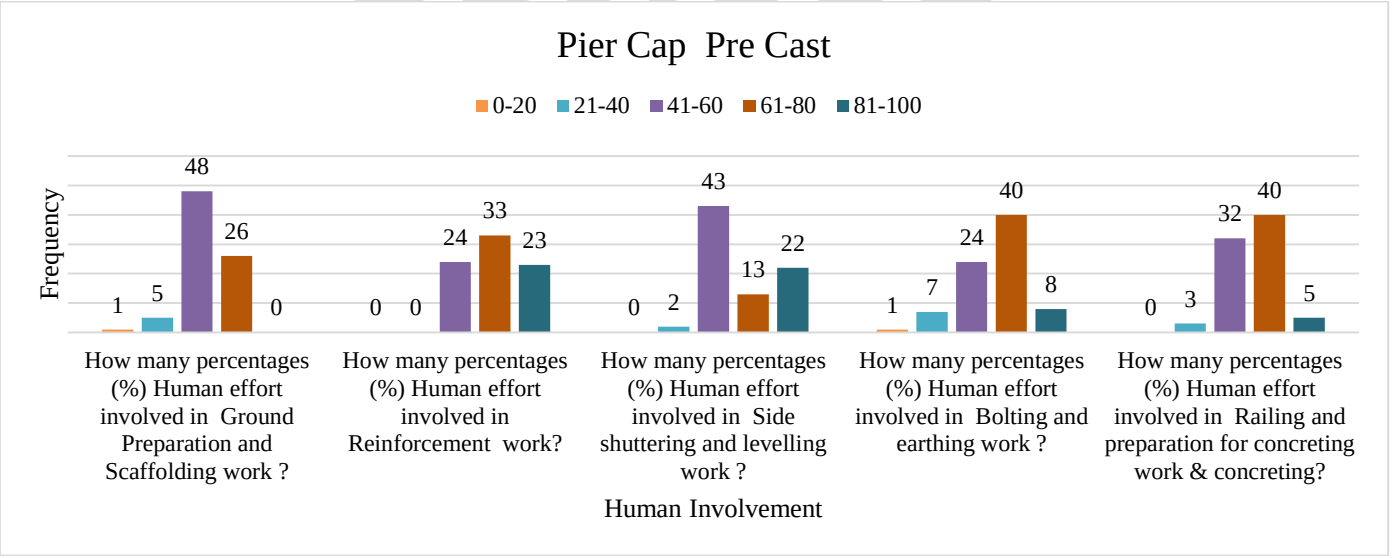
Graph 10Pier cap Cast in-situ human effort frequency

As per **Graph 11** shown the frequency of equipment effort involved in pier cap cast in-situ activities there is concrete work which is got a higher frequency among all.



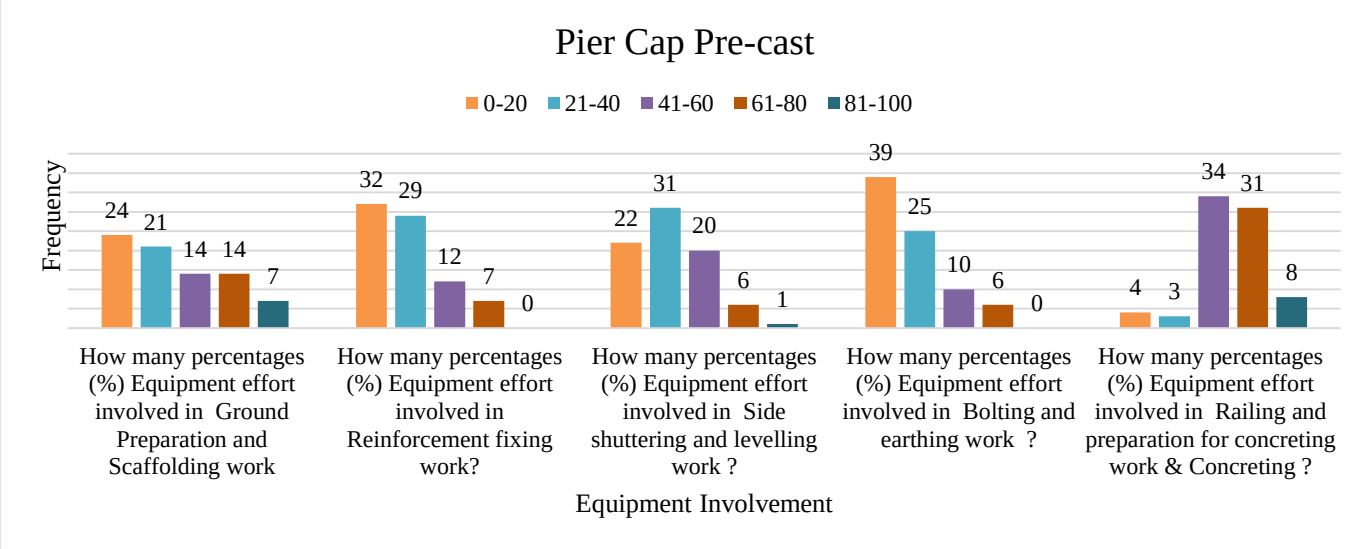
Graph 11 Pier cap Cast in-situ Equipment effort frequency

As per **Graph 12** shows in pier cap pre-cast component there are five activities among them all are have similar kind of frequency in terms of human effort involvement.



Graph 12 Pier Cap Pre cast human effort involvement frequency

As per **Graph 13** shows earthing work and reinforcement work got higher frequency in term of less equipment effort involvement.



Graph 13 Pier cap Pre-cast equipment effort involvement frequency

Measurement of central tendency

In In descriptive analysis, find the average response to a given activity. It is important to find a central position on the answers. Central tendency is measured by mean, median. Here below **Table 4** shows the results of the central tendency of our collected data.

Table 4 Central tendency

Title	N	Mean	Median	Variance	Minimum	Maximum
Pile						
Human effort						
How many percentages (%) involved in Pile Boring?	80	1.89	1	1.24	1	5
How many percentages (%) involved in Pile cage reinforcement work (Binding to placing)?	80	3.28	3	0.911	2	5
How many percentages (%) involved in Pile concrete work?	80	2.03	1	1.493	1	5
How many percentages (%) involved in removal of casing?	80	2.7	3	0.441	1	4
Equipment Effort						
How many percentages (%) involved in Pile boring?	80	4.54	5	0.581	2	5
How many percentages (%) involved in Pile cage reinforcement work (Binding to Placing)?	80	3.84	4	1.302	1	5
How many percentages (%) involved in Pile concrete work?	80	3.8	4	0.668	1	5
How many percentages (%) involved in Pile casing removal?	80	2.21	2	0.853	1	4
Pile Cap						
Human effort						
How many percentages (%) involved in Excavation and marking of points?	80	2.24	2	1.12	3	5
How many percentages (%) involved in PCC work?	80	4.31	4	0.369	1	5
How many percentages (%) involved in Pile chipping?	80	2.91	3	0.511	1	5

Title	N	Mean	Median	Variance	Minimum	Maximum
How many percentages (%) involved in PIT test?	80	2.08	2	1.184	2	5
How many percentages (%) involved in Reinforcement laying and fixing?	80	4.45	5	0.504	2	5
How many percentages (%) involved in Side shuttering and Earthing work?	80	4.39	4	0.443	2	5
How many percentages (%) involved in Concreting work?	80	3.43	3	0.45	1	5
How many percentages (%) involved in Curing?	80	4.38	5	0.87	1	5
Equipment Effort						
How many percentages (%) involved in Excavation and marking of points?	80	3.4	3	0.572	1	5
How many percentages (%) involved in PCC Work?	80	1.69	1	1.306	1	5
How many percentages (%) involved in Pile chipping?	80	3.83	4	0.779	1	5
How many percentages (%) involved in Reinforcement laying and fixing?	80	1.66	1	1.011	1	5
How many percentages (%) involved in Side shuttering and Earthing work?	80	1.7	1	1.073	1	5
How many percentages (%) involved in concrete work?	80	3.28	3	0.531	1	5
How many percentages (%) involved in curing?	80	1.63	1	0.794	3	5
Pier						
Human effort						
How many percentages (%) involved in Pier starter reinforcement and lapping of bars?	80	3.81	4	0.653	3	5
How many percentages (%) involved in Shuttering and concreting of piers?	80	3.9	4	0.572	2	5
How many percentages (%) involved in Staging of pier?	80	3.69	4	0.319	1	5
How many percentages (%) involved in Reinforcement fixing work?	80	3.81	4	0.838	2	5
How many percentages (%) involved in Earthing and shuttering work?	80	3.7	4	0.567	1	5
How many percentages (%) involved in Checking of levelling and concreting?	80	3.5	4	0.43	1	5
Equipment Effort						
How many percentages (%) involved in Pier starter reinforcement and lapping of bars?	80	2.01	2	1.126	1	4
How many percentages (%) involved in Shuttering and concreting of piers?	80	2.29	2	0.815	1	5
How many percentages (%) involved in Staging of pier?	80	2.42	2	1.134	1	4

Title	N	Mean	Median	Variance	Minimum	Maximum
How many percentages (%) involved in Reinforcement fixing work?	80	1.89	2	0.607	1	4
How many percentages (%) involved in Earthing and shuttering work?	80	1.83	2	0.779	1	5
How many percentages (%) involved in Checking of levelling and concreting?	80	3.54	4	0.783	2	5
Pier Cap Cast in situ						
Human effort						
How many percentages (%) involved in Reinforcement work?	80	3.89	4	0.734	1	5
How many percentages (%) involved in Staging and scaffolding work?	80	3.73	4	0.556	2	5
How many percentages (%) involved in Concrete work?	80	3.68	4	0.45	1	5
How many percentages (%) involved in Curing?	80	3.93	4	0.779	1	5
Equipment Effort	80					
How many percentages (%) involved in Reinforcement work?	80	2.15	2	0.965	1	5
How many percentages (%) involved in Staging and scaffolding work	80	2.48	2	1.012	1	5
How many percentages (%) involved in Concrete work?	80	3.14	3	0.424	1	4
How many percentages (%) involved in curing?	80	1.59	1	0.625	1	4
Pier Cap Pre cast						
Human effort						
How many percentages (%) involved in Ground Preparation and Scaffolding work?	80	3.24	3	0.386	3	5
How many percentages (%) involved in Reinforcement work?	80	3.99	4	0.595	2	5
How many percentages (%) involved in Side shuttering and levelling work?	80	3.69	3	0.825	1	5
How many percentages (%) involved in Bolting and earthing work?	80	3.59	4	0.701	2	5
How many percentages (%) involved in Railing and preparation for concreting work & concreting?	80	3.59	4	0.448	1	5
Equipment Effort						
How many percentages (%) involved in Ground Preparation and Scaffolding work	80	2.49	2	1.747	1	4
How many percentages (%) involved in Reinforcement fixing work?	80	1.93	2	0.906	1	5

Title	N	Mean	Median	Variance	Minimum	Maximum
How many percentages (%) involved in Side shuttering and levelling work?	80	2.16	2	0.923	1	4
How many percentages (%) involved in Bolting and earthing work?	80	1.79	2	0.878	1	5
How many percentages (%) involved in Railing and preparation for concreting work & Concreting?	80	3.45	3	0.833	1	5

Results of descriptive analysis

The Percentage of human and equipment effort is resulting with the help of Descriptive analysis, with orientation to the mean of various activities of sub structure that accomplish our objective, Here below **Table 5** given the results of descriptive analysis.

Table 5 result of descriptive

Title	Human effort involvement	Equipment Effort involvement
Pile		
How many percentages (%) involved in Pile Boring?	37.8%	90.8%
How many percentages (%) involved in Pile cage reinforcement work (Binding to placing)?	65.6%	76.8%
How many percentages (%) involved in Pile concrete work?	40.6%	76%
How many percentages (%) involved in removal of casing?	54%	44.2%
Pile cap		
How many percentages (%) involved in Excavation and marking of points?	44.8%	68%
How many percentages (%) involved in PCC work?	86.2%	33.8%
How many percentages (%) involved in Pile chipping?	58.2%	76.6%
How many percentages (%) involved in PIT test?	41.6%	33.2%
How many percentages (%) involved in Reinforcement laying and fixing?	89%	34%
How many percentages (%) involved in Side shuttering and Earthing work?	87.8%	65.6%
How many percentages (%) involved in Concreting work?	68.6%	32.6%
How many percentages (%) involved in Curing?	87.6%	26.4%
Pier		
How many percentages (%) involved in Pier starter reinforcement and lapping of bars?	76.2%	40.2%
How many percentages (%) involved in Shuttering and concreting of piers?	78%	45.8%
How many percentages (%) involved in Staging of pier?	73.8%	48.4%
How many percentages (%) involved in Reinforcement fixing work?	76.2%	37.8%
How many percentages (%) involved in Earthing and shuttering work?	74%	36.6%
How many percentages (%) involved in Checking of levelling and concreting?	70%	70.8%
Pier Cap (cat in-situ)		

Title	Human effort involvement	Equipment Effort involvement
How many percentages (%) involved in Reinforcement work?	77.8%	44.8%
How many percentages (%) involved in Staging and scaffolding work?	74.6%	86.2%
How many percentages (%) involved in Concrete work?	73.6%	58.2%
How many percentages (%) involved in Curing?	78.6%	41.6%
Pier cap (pre-cast)		
How many percentages (%) involved in Ground Preparation and Scaffolding work?	64.8%	49.8%
How many percentages (%) involved in Reinforcement work?	79.8%	38.6%
How many percentages (%) involved in Side shuttering and levelling work?	73.8%	43.2%
How many percentages (%) involved in Bolting and earthing work?	71.8%	35.8%
How many percentages (%) involved in Railing and preparation for concreting work & concreting?	71.8%	69%

To sum up everything that can consider the involvement of human and equipment at components than Pier cap (cast in-situ) and Pier has higher involvement of human effort and Pile has higher involvement of Equipment effort. **Table 6** presents that below,

Table 6 overall effort involvement

Components	Human Effort Involvement (%)	Equipment effort Involvement (%)
Pile	49.5	71.95
Pile Cap	70.475	46.275
Pier	74.7	51.04
Pier Cap (Cast in-situ)	76.15	57.7
Pier Cap (Pre-cast)	72.4	47.28

As **Table 7** shown below overall the bridge sub structure have 68.64 % human effort involvement & 54.84 % equipment effort involved.

Table 7 HE & EF involvement in super structure

Part	Human Effort Involvement	Equipment effort Involvement
Sub structure	68.64%	54.84%

Cost analysis

To verify the results of the descriptive analysis a case study of the bridge project has been taken for cost analysis of project to get the comparative results to analysis cost with respect to the descriptive results. In a sub structure of the bridge project there are various components available which consist Pile, Pile cap, Pier as well as Pier cap. The quantity of the sub structure components given beneath,

Table 8 sub structure components

Sub Structure quantity	
Components	**Number of Items**
Pile	352
Pile cap	76
Pier	76
Pier cap	76

In bridge construction there are always two effort involved from sub structure of bridge consist human and equipment effort in which human effort embrace steel work, concrete wages and scaffolding work and equipment effort include excavation, steel cutting machine, concrete work has batching plant and concrete pump activity. Here below the cost analysis of the sub structure contain human and equipment cost,

Table 9 Sub Structure cost analysis

Sub Structure Cost Analysis			
Components	**HE**	**EE**	**Total Cost**
Pile	27,24,000.00	2,44,93,500.00	2,72,17,500.00
Pile Cap	11,91,000.00	33,34,900.00	45,25,900.00
Pier	15,49,000.00	12,05,000.00	27,54,000.00
Pier Cap	31,14,493.00	20,13,000.00	51,27,493.00
Total	**85,78,493.00**	**3,10,46,400.00**	**3,96,24,893.00**

Here **Table 10** shows results of the sub structure cost in which pile equipment cost has 2,44,93,500 INR because of the pile rig machine and several activities related pile along the line of steel cutting and placing to the concrete pouring work consist the equipment that causes cost higher. If talk about pile cap has a requirement of excavator which makes equipment cost 33,34,900 INR. At the sub structure there is an always an equipment cost win the game in compare with the human effort here there is 3,10,46,400 INR equipment cost on the other hand human effort has a 85,78,493 INR cost, which is less than an equipment effort.

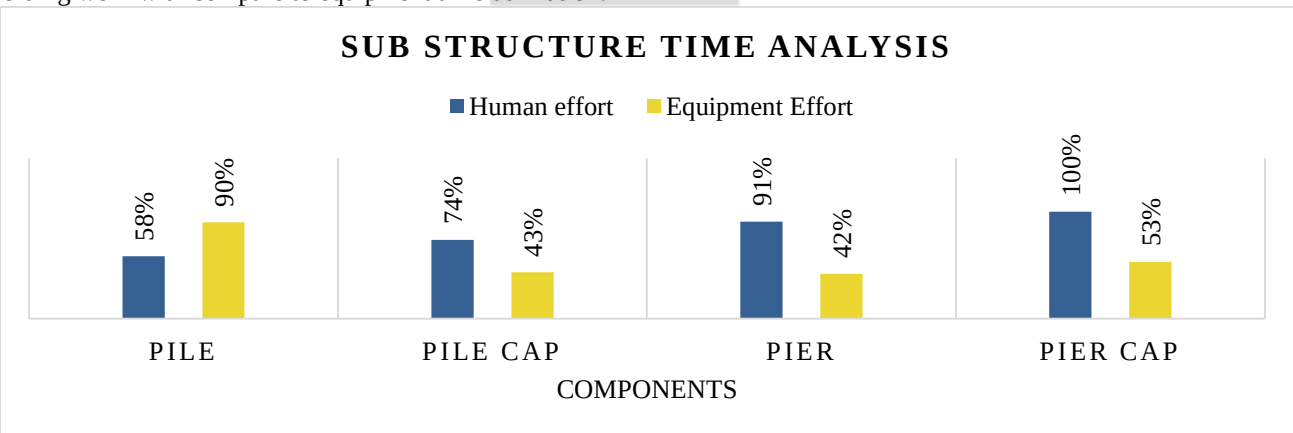
Table 10 Sub structure (%) cost analysis

Sub Structure Cost Analysis		
Components	**HE**	**EE**
Pile	7%	62%
Pile Cap	3%	8%
Pier	4%	3%
Pier Cap	8%	5%
Total	**22%**	**78%**

The above table presents the human and equipment effort percentage in compare with total effort, Pile get the 62% value of EE and 7% in HE which is valid as per our descriptive analysis. In addition, Pile cap also get the appropriate result because pile cap also utilize a more equipment effort in compare with human. Further when project progress there is a pier as well as pier cap which is consist more human effort than equipment.

Time analysis

Time Analysis were done to identify various activities time consumption of sub structure components along the line of Pile, Pile cap, Pier as well as Pier cap. Here beneath the graph of the time utilization given in that if illustrate pile then human effort and equipment effort has 34 % and 90% respectively utilize time. If take a look on pile cap that's got human effort higher as74% consist more time in steel cutting, laying and fixing work as well as shuttering work. Moreover, Pier and pier cap has a 91% and 100% in human time consumption because these are the components activities utilize more human effort on reinforcement work and scaffolding work with compare to equipment time utilization.



Graph 14 Sub structure (%) time analysis

VII. CONCLUSION

This research work identified the activities associated with components such as Pile, Pile cap, Pier and Pier cap to know the efficiency of human and equipment within the sub-structure of the bridge project. Which were kept percentage based on involvement. The data collected from this was taken from the opinions of about 80 participants who are involved in bridge construction and the analysis of this collected data has been done with the help of descriptive analysis and SPSS software.

Analysis of all these data revealed the involvement of human and equipment in the sub-structure of the bridge, out of which if talk about one of the component piles in the bridge component, the involvement of human effort was 49.5% which is less than equipment effort while equipment. The effort was found to be 72% due to other activities associated with it. Interestingly, The result of Pile cap increased by 70.47%. In comparison, equipment effort was found to be 46.275% due to human related activities like reinforcement work, shuttering work. The amount of human effort is more than the equipment. Further, talking about the pier as well as the pier cap that saw a slight change in the involvement of human and equipment. As 74.61% and 74% saw human effort in pier and pier cap respectively and on the other hand 55.04%, 52% saw proportion of equipment in pier and pier cap respectively. Combining all this, 68.64% human effort was involved and 54.84% equipment contributed to the total bridge substructure.

This research work will be useful for those involved in bridge construction as if the amount of human and equipment effort on the construction project is known then the work can be planned accordingly so as to increase the productivity of the work. For those working in the bridge sector, this research work can be used and can lead to automation in equipment in the bridge sector so that human involvement can be reduced and work can be completed quickly at low cost by improving the quality of work.

REFERENCES

1. Agrawal, A. a. (2020). Identifying factors affecting construction labour productivity in India and measures to improve productivity. *Asian Journal of Civil Engineering 21.4*, 569-579.
2. Bao, R. M.-F. (2016). Characterizing construction equipment activities in long video sequences of earthmoving operations via kinematic features. *Construction Research Congress 2016*.
3. Cheng, T. e. (2013). Automated task-level activity analysis through fusion of real time location sensors and worker's thoracic posture data. *Automation in Construction 29*, 24-39.
4. Coffey, M. (2000). Developing and maintaining employee commitment and involvement in lean construction. *In Proceedings of the 8th annual conference of the International Group for Lean Construction*, 17-19.
5. Desai, P. A. (September- 2019). Labour Productivity Measurement for Precast Fly Over Bridge Construction Project. *International Journal of Engineering Research & Technology (IJERT)*, Vol.8,pg. 230-234.
6. Gouett, M. C. (2010). Activity analysis for continuous productivity improvement in construction. *MS thesis. University of Waterloo*.
7. Gouett, M. C. (2011). Activity analysis for direct-work rate improvement in construction. *Journal of Construction Engineering and Management 137.12* , 1117-1124.
8. Gurmu, A. T. (2017). Construction equipment management practices for improving labor productivity in multistory building construction projects. *Journal of Construction Engineering and Management 143.10*, 04017081.
9. Hernandez, C. e. (2019). A deep learning framework for construction equipment activity analysis. *VA: American Society of Civil Engineers*, 479-486.
10. Hickson, B. G. (2014). Factors affecting construction labour productivity in Trinidad and Tobago. *The Journal of the Association of Professional engineers of Trinidad and Tobago*, 4-11.
11. Karunarathna, D. M. (July-2019). An Activity Analysis to Investigate the Root Causes of Worker Productivity Losses in Sri Lankan Building Construction Project. *Moratuwa Engineering Research Conference (MERCon)*.
12. M. Waris, M. S. (June-2014). Criteria for the selection of sustainable onsite construction equipment. *International Journal of Sustainable Built Environment 3.1*, 96-110.
13. Manikandan, M. M. (2018). A study and analysis of construction equipment management used in construction projects for improving productivity. *Int Res J Eng Technol (IRJET)*, 1297-1303.
14. Pradhananga, N. a. (2013). Automatic spatio-temporal analysis of construction site equipment operations using GPS data. *Automation in Construction 29* , 107-122.
15. Roberts, D. e. (2020). Vision-based construction worker activity analysis informed by body posture. *Journal of Computing in Civil Engineering 34.4*, 04020017.
16. Shahtaheri, M. (2012). Setting target rates for construction activity analysis categories. *MS thesis. University of Waterloo*.

VIII. ACKNOWLEDGEMENT

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully.

I would like to express my deep and sincere gratitude to my research guide, **Prof. Ankit S. Patel**, for giving me the opportunity to do research and providing invaluable guidance throughout this research. His dynamism, vision, sincerity and motivation have deeply inspired me. He has taught me the methodology to carry out the research and to present the research works as clearly as possible. It was a great privilege and honor to work and study under his guidance. I am extremely grateful for what he has offered me. I would also like to thank him for his friendship, empathy, and great sense of humor.

I am extremely grateful to my parents for their love, prayers, caring and sacrifices for educating and preparing me for my future. My Special thanks goes to colleague and brother for the keen interest shown to complete this thesis successfully.