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STATISTICAL DETERMINATION OF THE MOST SUITABLE WAY OF PERFORMING BEAM REACTIONS EXPERIMENT

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ABSTRACT
Beam reactions experiment is an experiment of the subject Engineering Mechanics of First Year Engineering courses for all Branches of Engineering, under University of Mumbai. In this experiment the reactions at the supports of a simply supported wooden beam are measured.The beam is supported by spring so that the deflection at the end supprots can be measured with the help of a pointer connected to the spring. The spring at both the ends deflects in proportion to the applied load and the distance of the load from the support. The reactions are also calculated analytically and compared with the experimental results.While students performed experiments on the set up, it was observed that experiments can be performed either by considering the current position of the pointer as the initial position and then noting the values corresponding to the position of pointer after application of load or by adjusting the spring tension so as to bring the pointer to zero position and then performing the experiment..It was very difficult to convey the students about the better of the two methods. Considering this difficulty it was decided to find the better of the two methods experimentally. The current paper discusses about the better method of the two by performing and then statistically analysing the data.

Keywords
Beam reactions experiment,Coeifficient of correlation.

1. INTRODUCTION
Use of specific methods,tools and techniques for the continuos improvement of the teaching learning process is a subject of research since long time[1]. Different researchers use different methods for improving the learning of students. A few have used improved course evaluation techniques to achive the goals of the accreditation board[2], while a few have used internet as the tool for effective learning where 4 environments have been developed namely remote experimentation, mathematical analysis, dynamic simulation, and self-learning[3].Some more strategies propose use of Face Book for teaching and learning improvement[10]. In some other cases the researchers have proposed control system inventory to check the understanding of the students.[4]. In one of the papers a strategy for the ideas of students,converting them to instructions and ability to do calculations were assessed by a web based Test of Line (ToL) method.[5].This helps faculties to understand the shortcomings of students so that corrective action can be taken depending on their weaknesses. It is also important to develop the ethical values in students so that they will be not only honest in making observatiions while they perform practicals but also during their service for any organization. From this point of view a few researchers have carried out research from a social perspective[6,8].It is also required to make positive changes in the curriculum of a given course in engineering so that its main focus should be on innovations and high level technical management [7,9].Study also shows the use of some techniques where students group assignments can be led to team projects which will be useful for assessment of skills of students[11].The current paper is based on the fact that students should be aware of the effective method for performing the given experiment based on some facts.This will lead to more accurate results as well as avoid confusion of the better method.Hence readings were taken by the two possible methods of performing the beam reactions experiment,and then statistically analysing the data obtained from the experiments.Beam reactions experiment consists of a simply supported wooden beam.The two ends of the beam have spring which is attached to a pointer which indicates the deflection at the support.Once load is applied on the beam the pointer at both the ends shows readings which depends on the amount of load as well as its position. Two calibrated scales provided on the front at each end of the set up are used to measure the load on the beam. The measured reactions are then compared with the analytical values obtained by the use of conditions of equilibrium. The experiment can be done either by adjusting the spring tension so that the pointer on the scales will move to zero which can be termed as "With zero setting" or considering the current position of the pointer as the initial reading and substracting this from the final reading so as to get the actual rading which can be termed as "Without Zero Settings". It was always found difficult to convince the students about the better of the two methods. In order to overcome this difficulty, readings were taken for the same given conditions of X_1,X_2,W_1 and W_2 by both the methods and the output readings of Ra and Rb were measured.The readings were then analysed statistically to arrive at a conclusion of the better method.

2. EXPERIMENTAL SET UP
The experimental set up consists of a horizontal wooden beam simply supported by two steel supports at both the ends. The beam rests on spring on the supports provided at both the ends. The springs are calibrated to measure their deflections in kilograms which is indicated by the deflection of a pointer on a circular graduated scale. The beam has grooves at 50mm distance on its top surface and a scale on the front end as shown in Fig.1 and 2. The total length of the beam is 1000mm. Weights can be hung in the hangers at the grooves provided on the top surfaces. The experiment was conducted by noting the distance X_1 and X_2 from the left support. The load was then attached in the hangers on the beam and the

corresponding readings indicated by the graduated scale and pointer provided on the front side are noted.These deflections indicate the reactions at the supports A and B. Readings were taken with the same value of X_1,X_2,W_1 and W_2 by both the methods. In the first method the initial position of the pointer was adjusted to zero and then the weights were applied and the readings were taken while in the second method the pointer was kept at its current position and weights were applied. The readings were then taken in the form of initial and final readings and the substraction of both gives the value of reactions Ra and Rb. The experiment was conducted by the same person, at the same place and at the same time.

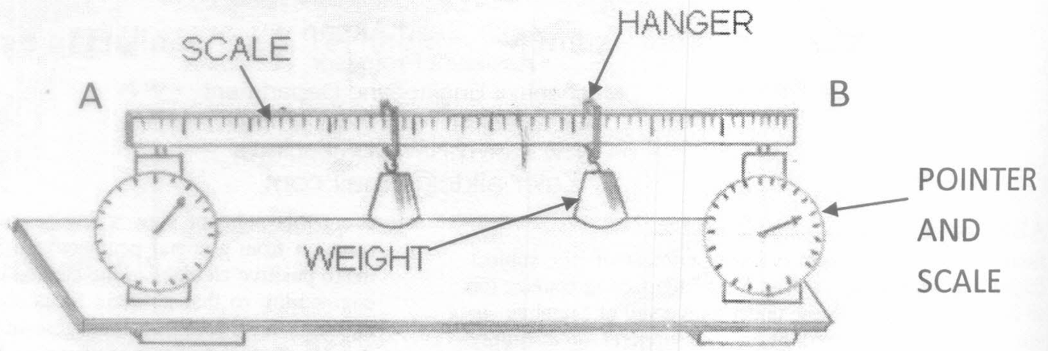

Fig.1 Beam reaction experimental setup

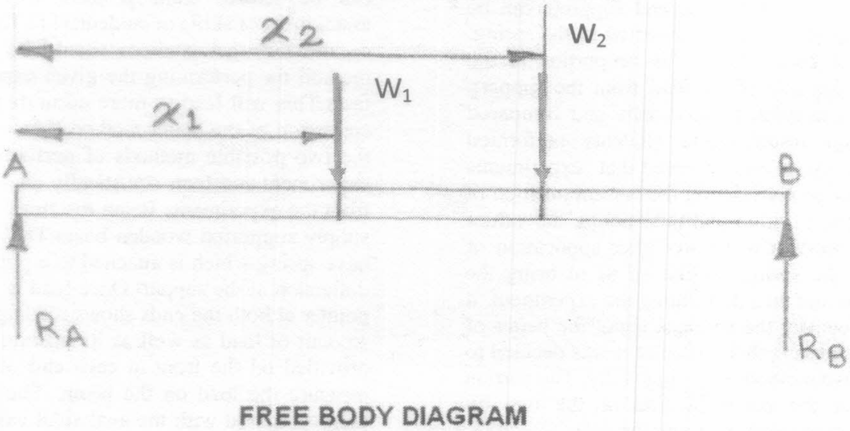

Fig.2 Free Body Diagram of beam reactions experimental setup

2.1 Preliminary Discussion on Sources of Errors.

It is found that for analysis of errors the fish Bone diagram is a very useful tool [1].A preliminary analysis was done by Fish Bone diagram for finding out the major sources of errors during the experiment as indicated in Fig.3. It was observed that there are three main sources from where the errors may get introduced, first one is the observer,secondly the mass which is hung on the beam which acts as load and the last is the spring balance for setting the pointer at zero position. It was found by observation that the factor that affects more towards introduction of error was the observer.

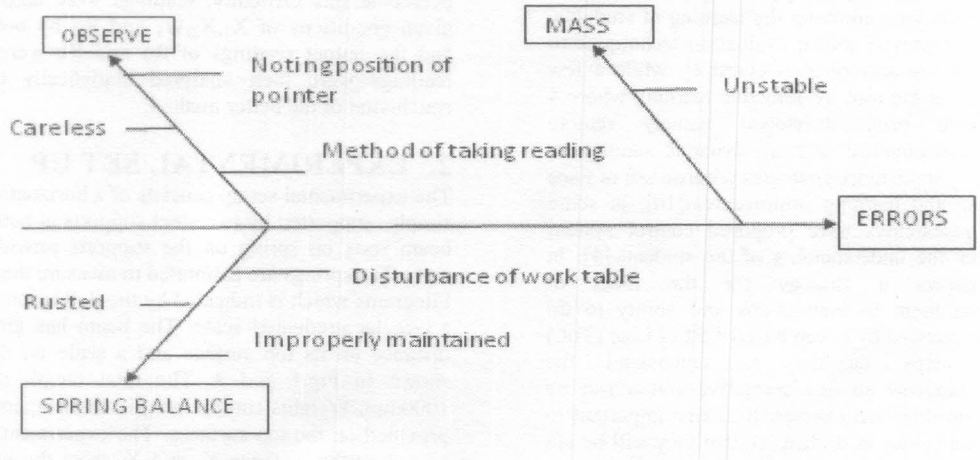

Fig.3 Fish Bone diagram for finding the factors affecting the output

3. CONDUCTION OF EXPERIMENT

The experiment was conducted firstly by considering the current position of the pointer as the initial reading (Ra/Rb)i and then noting down the observations after application of the load and considering this to be the final reading (Ra/Rb)f. The difference of the two is the actual reading. The observations made in this case are as indicated in Table 1 Secondly the experiment was conducted by the same observer under the same conditions at the same time only by changing the method of conducting the experiment. Here the method adopted is adjusting the position of the pointer to zero after every set of observation. The readings obtained by this method are as shown in Table 2.

3.1 Analysis of Data

The data obtained was analysed to determine the correlation of the experimental values of the reactions at supports with their respective analytical values. The standard deviation and the coeifficient of correlation was determined from the obtained readings. Also the variation between the experimental and anlytical values for each set of experiment were seen with the help of Pareto diagram.

Table 1. Experimental results for the experiment without presetting of the pointer

Sr. No.	X_1 (m)	X_2 (m)	W_1 (Kg)	W_2 (Kg)	(Ra)i (Kg)	(Ra)f (Kg)	Ra exp (Kg)	Ra (Kg)	(Rb)i (Kg)	(Rb)f (Kg)	Rb exp (Kg)	Rb (Kg)
1	0.1	0.9	1	1	0.3	1.25	0.95	1	0.25	1.25	1	1
2	0.15	0.85	1	1	0.3	1.3	1	1	0.25	1.25	1	1
3	0.2	0.8	1	1	0.3	1.25	0.95	1	0.25	1.2	0.95	1
4	0.25	0.75	1	1	0.3	1.25	0.95	1	0.25	1.25	1	1
5	0.3	0.7	1	1	0.3	1.25	0.95	1	0.25	1.2	0.95	1
6	0.35	0.65	1	1	0.3	1.25	0.95	1	0.25	1.2	0.95	1
7	0.4	0.6	1	1	0.3	1.25	0.95	1	0.3	1.2	0.9	1
8	0.45	0.55	1	1	0.35	1.2	0.85	1	0.3	1.2	0.9	1
9	0.4	0.55	1	1	0.35	1.3	0.95	1.05	0.3	1.15	0.85	0.95
10	0.35	0.55	1	1	0.3	1.35	1.05	1.1	0.25	1.1	0.85	0.9
11	0.3	0.55	1	1	0.35	1.4	1.05	1.15	0.25	1.1	0.85	0.85
12	0.25	0.55	1	1	0.35	1.4	1.05	1.2	0.25	1	0.75	0.8
13	0.2	0.55	1	1	0.35	1.55	1.2	1.25	0.25	1	0.75	0.75
14	0.15	0.55	1	1	0.35	1.55	1.2	1.3	0.25	1	0.75	0.7
15	0.1	0.55	1	1	0.35	1.6	1.25	1.35	0.25	0.85	0.6	0.65
16	0.1	0.6	1	1	0.3	1.55	1.25	1.3	0.25	0.8	0.55	0.7
17	0.15	0.6	1	1	0.3	1.55	1.25	1.25	0.25	0.9	0.65	0.75
18	0.2	0.6	1	1	0.3	1.45	1.15	1.2	0.25	1	0.75	0.8
19	0.25	0.6	1	1	0.35	1.35	1	1.15	0.25	1.05	0.8	0.85
20	0.3	0.6	1	1	0.3	1.35	1.05	1.1	0.25	1.2	0.95	0.9
21	0.35	0.6	1	1	0.3	1.35	1.05	1.05	0.25	1.2	0.95	0.95
22	0.4	0.6	1	1	0.3	1.2	0.9	1	0.25	1.2	0.95	1
23	0.45	0.6	1	1	0.35	1.15	0.8	0.95	0.3	1.25	0.95	1.05
24	0.45	0.65	1	1	0.4	1.1	0.7	0.9	0.3	1.35	1.05	1.1
25	0.4	0.65	1	1	0.4	1.2	0.8	0.95	0.3	1.3	1	1.05
26	0.35	0.65	1	1	0.4	1.15	0.75	1	0.3	1.2	0.9	1
27	0.3	0.65	1	1	0.4	1.3	0.9	1.05	0.25	1.15	0.9	0.95
28	0.25	0.65	1	1	0.35	1.3	0.95	1.1	0.25	1.1	0.85	0.9
29	0.2	0.65	1	1	0.35	1.4	1.05	1.15	0.25	1.1	0.85	0.85
30	0.15	0.65	1	1	0.4	1.45	1.05	1.2	0.25	1	0.75	0.8
31	0.1	0.65	1	1	0.4	1.5	1.1	1.25	0.25	0.95	0.7	0.75
STANDARD DEVIATION							0.1429	0.1211			0.1259	0.1211
COEIFFICIENT OF CORRELATION							0.906057				0.933214	
r^2							0.820939				0.870888	
% OF CORRELATION							82.09386				87.08878	

Table 2. Experimental results for the experiment with presetting of the pointer

Sr. No.	X_1 (m)	X_2 (m)	W_1 (Kg)	W_2 (Kg)	Ra exp (Kg)	Ra (Kg)	Rb exp (Kg)	Rb (Kg)
1	0.1	0.9	1	1	1	1	0.95	1
2	0.15	0.85	1	1	1	1	0.95	1
3	0.2	0.8	1	1	1	1	0.9	1
4	0.25	0.75	1	1	0.85	1	1	1
5	0.3	0.7	1	1	0.9	1	1	1
6	0.35	0.65	1	1	0.9	1	1	1
7	0.4	0.6	1	1	0.95	1	1	1
8	0.45	0.55	1	1	0.95	1	0.9	1
9	0.4	0.55	1	1	1	1.05	0.95	0.95
10	0.35	0.55	1	1	1	1.1	0.85	0.9
11	0.3	0.55	1	1	1.1	1.15	0.8	0.85
12	0.25	0.55	1	1	1.1	1.2	0.75	0.8
13	0.2	0.55	1	1	1.2	1.25	0.75	0.75
14	0.15	0.55	1	1	1.2	1.3	0.7	0.7
15	0.1	0.55	1	1	1.25	1.35	0.65	0.65
16	0.1	0.6	1	1	1.25	1.3	0.65	0.7
17	0.15	0.6	1	1	1.1	1.25	0.7	0.75
18	0.2	0.6	1	1	1.15	1.2	0.75	0.8
19	0.25	0.6	1	1	1	1.15	0.8	0.85
20	0.3	0.6	1	1	0.9	1.1	0.85	0.9
21	0.35	0.6	1	1	0.85	1.05	0.9	0.95
22	0.4	0.6	1	1	0.85	1	0.95	1
23	0.45	0.6	1	1	0.9	0.95	0.9	1.05
24	0.45	0.65	1	1	0.9	0.9	1.05	1.1
25	0.4	0.65	1	1	0.65	0.95	0.95	1.05
26	0.35	0.65	1	1	0.85	1	0.9	1
27	0.3	0.65	1	1	0.9	1.05	0.9	0.95
28	0.25	0.65	1	1	0.95	1.1	0.85	0.9
29	0.2	0.65	1	1	0.95	1.15	0.75	0.85
30	0.15	0.65	1	1	0.9	1.2	0.8	0.8
31	0.1	0.65	1	1	1	1.25	0.7	0.75
				STANDARD DEVIATION	0.134404	0.113829	0.121062	0.121062
				COEIFFICIENT OF CORRELATION		0.795653		0.947863
				r^2		0.633064		0.898444
				% OF CORRELATION		63.30643		89.84438

4. RESULTS AND CONCLUSIONS

From the Pareto diagram it is clear that for the case with zero settings,the experimental value of the reaction at support A is always either lesser than or equal to (100% cases) their analytical values so it can be said that the observations for reactions at end A are to be always taken on the higher side. In the similar way the the reactions at support B for the same case are also smaller than their analytical values so similar conclusion is also drawn for the reactions at end B. For the second case without zero settings, for the reactions at end A as well as at end B it is found from the Pareto diagram that the experimental values of reactions are always smaller than their analytical values so care should be taken during experiment performance to consider them on the higher side. Reffering to Table 1 and 2 it can be concluded that for the case with zero settings, there exist 82% correlation between the experimental and analytical values of reactions at support A (Ra) while 87% correlation exists for the reactions at support B (Rb). Similarly for the case without zero settings the correlation between experimental and analytical values of reactions at support A (Ra) is 63% while for reactions at support B (Rb) it is 89%. It can be said that more the correlation between the experimental and analytical values, less is the error and more is the accuracy.From these quantitative values it can be concluded that as the correlation for the values of reactions at support B by the method with zero settings is more than its value without zero settings hence it is recommended to perform the experiment by adjusting the pointer to zero for every set of readings.

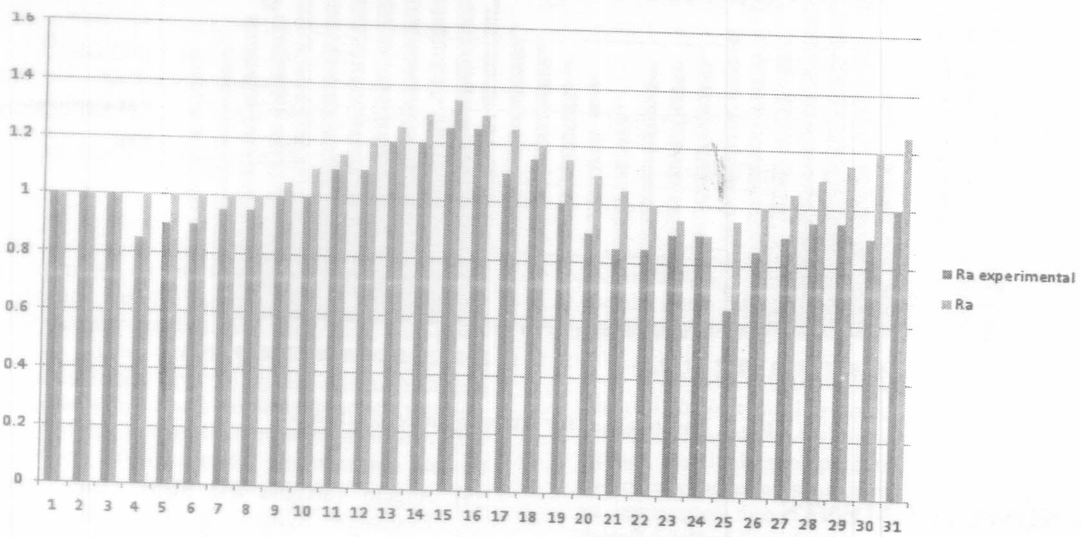

Fig 4: Pareto chart for Ra with zero settings

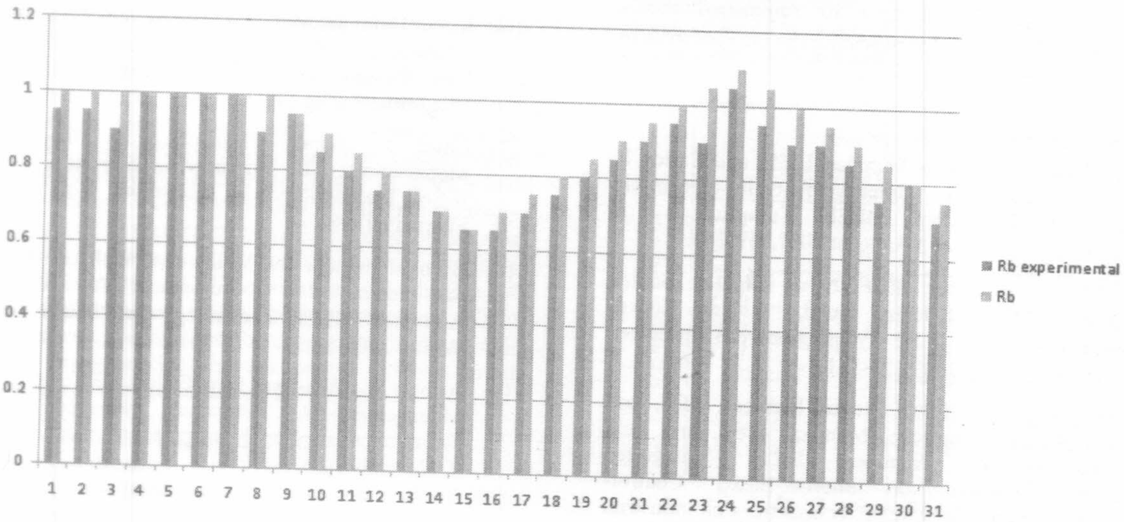

Fig 5: Pareto chart for Rb with zero settings

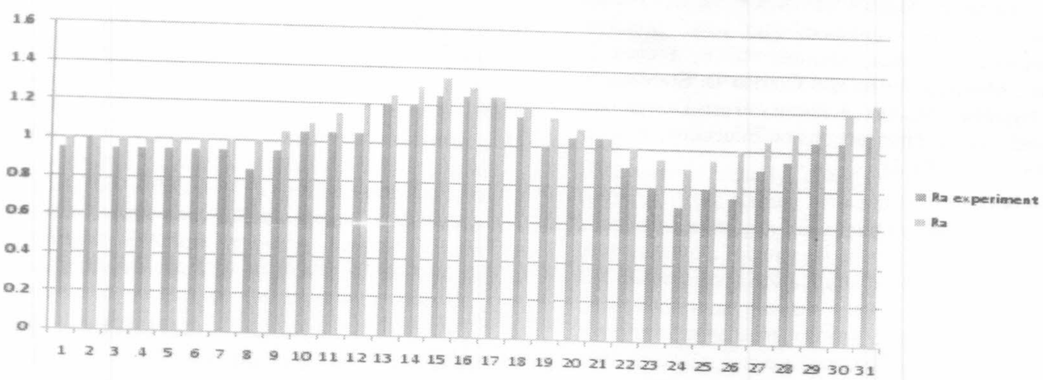

Fig 6: Pareto chart for Ra without zero settings

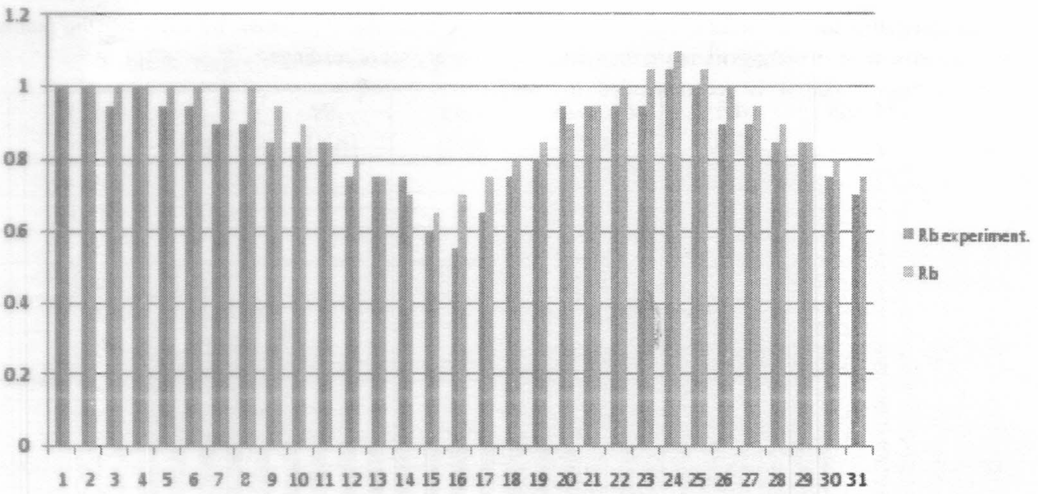

Fig 7: Pareto chart for Rb without zero settings

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