Software Assisted Fabrication of Hull Blocks of Ship

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Abstract:- Accuracy control of block fabrication in shipyards is vital for its success. Almost all premier shipyards now a days uses modular construction methods from 1980. To excel in modular construction the accuracy of block fabrication is of prime most important requirement, hence it is one of the challenges faced by all shipyards. The advantage of accuracy control is that it reduces the cycle time, reduces rework, increase quality standards to meet the future challenges. The many shipyards adopts different methods to achieve the accuracy in the block fabrication. Some yards adopted the method of working with the extra/Green material to achieve the required accuracy. The one of the main disadvantage of working with extra/Green material is that the dock availability is getting increased there by increasing the cycle time. The other disadvantage of poor accuracy control is that it will lead to rework due to the mismatch with the near block there by increase the cost of repair. The cost of rework will not be able to judge accurately as it has far reaching consequence, sometimes it may even affect the Master construction schedule there by leads to Liquidate damage (LD). The other necessity for achieving the very high accuracy control is that the many of the recent market trend vessel like LNG carriers requires very high block accuracy to place the CCS (Cargo containment system) hence without achieving the high accuracy these type of work will not be able to execute. The novel method which I am explaining here consist of two steps correcting the inaccuracy of the block with the help measurement done with the total station and comparing it with the design model and advance cutting of the extra material based on the model using the help of AUTOCAD and Total stations.

The methodology consist of making a dxf design model, two methods are being used for this first one consist of extracting directly from the Tribon software which the yard is using or by importing design coordinate data from excel to Autocad. The next step consist of creating a dxf actual model, with the use of EDM equipment. For EDM measurement total station are being used. The total station used for this methodology is Leica make total station having an accuracy of $\pm$ 1mm. The equipment is capable of measuring the 3D coordinate value these values are stored in the memory of the equipment and the same is saved as the dxf data. The dxf design model and dxf actual model are saved in a file of AUTOCAD and compare the same to find the variation and one of the challenge faced by the using the AUTOCAD is that it is not able to get a best fit with the design model and actual model. Hence a program has been developed in Autolisp to get a best fit.

After the codes has been developed the experiment was carried out on the vessel RO-RO (BY-106). There are five main units for this vessel and the experiment was carried on this vessels five unit, the experiments consist of checking the accuracy with the design and actual model with the help of software so that the blocks are fabricated well within the tolerance limit.

I. INTRODUCTION

CSL(Cochin Shipyard Ltd) is a premier organisation in India which manufacture different type of sea going vessel such as Air craft carrier, Fast petrol vessel, Bulk carrier, Oil tanker, Platform support vessel, Passenger vessel, Barge, RO-RO (Roll on/Roll off), etc. From my 10 years of experience in shipyard it is learned that lot of problems are generated due to the inaccuracies of the block which causes increasing the cycle time and increased rework. In block fabrication it is impossible to avoid the errors completely but if it can be reduced then lot of benefits can be achieved by reducing the cycle time to increase in profit per/Tonnage. The major source of inaccuracies are contributed by errors in cutting, improper shrinkage allowance, Improper welding procedure, Improper weld sequence, Improper fabrication sequence etc[3][4]. Here I am concentrating on software assisted evaluation to find out the variation, improve the accuracies of block fabrication. Further to reduce the error, after the complete fit up of block (Before the start of the welding) dimensional check is being carried with the help of total station and compare it with the model using the AUTOCAD. The one of the advantage of total station is that the output of the coordinate values are in dxf format hence the same can be easily convert to AUTO CAD. In CSL to reduce the inaccuracies, yard is working with extra/green material in the erection butts of the blocks (Place where the two blocks get joined) hence if any error the same can be adjusted by trimming in the site (dock), the disadvantage of this process is that cycle time is getting increased.

In the shipbuilding industry, accuracy control in block fabrication is vital to increase the productivity and to reduce the rework. This is accomplished by focusing attention on various process where improvement offer significant benefits, it also provides the mean for monitoring the work by individual work process or problem area, it is done by checking the process against the standards such as IACS 47I[2]nternational association for classification society-47) or Hull standards of the yard[1].

Ship production involves many stages of fabrication process. Throughout these processes it is expected that dimensional variation could occur and if it is not managed properly it could cause dimensional related problem which

will cause rework and delay which will increase the cycle time. The main disadvantage of inaccuracies are it will affect the advance outfitting or otherwise called IHOP (Integrated Hull Outfit and Painting). IHOP is a process in which all the items which are coming in its designated location will be placed in the Block stage itself.

The use of accuracy control system ensures that parts can be manufactured to the required dimensions and tolerance. This system will minimize the potential rework during product assembly and that assure product quality. In ship production this enables the building of large sections/Blocks with minimum dimensional variation and distortion that would require rework and potential impacting product performance. This ultimately equates to reduced production lower costs and good product quality. Accuracy control system in shipbuilding industries has proven to have reduced production time, rework, and improved productivity and finally achieved quality product[5].

An important aspect of accuracy control is the difficulty commonly encountered in joining blocks during hull erection. Erection joint gaps that are not within tolerance limits must be reworked by gas cutting and/or back strip welding to be adopted so that the automated welding cannot be adopted, thereby increasing cycle time. The novel method which is developed consist of comparing the block using AUTO CAD and Total station. To reduce the availability of dock usage the Extra material will be cut by comparing the actual block dimension obtained from the Total station and comparing it with the design model.

Accuracy control in shipbuilding originated in 1960's. the process innovation of ship designs and building methods, together with accuracy control helped Japanese shipyards become the most productive and competitive shipbuilders in the world. In the past fifteen years, accuracy control programs have been implemented by many U.S and Europe shipyards following the methodology used successfully in Japan[5].

The figure 1 and figure 2 shows schematic block arrangement and exploded view of the vessel respectively. In shipbuilding when different blocks are joined misalignment between the blocks are occurring and which lead to difficulty of the welding due to uneven gap created due to misalignment.

➢ *Objective*
• To improve the accuracy of the block with the help of a program developed, by comparing with the design model and actual model.

II. METHOD FOR CORRECTING THE INACCURACY OF THE BLOCK

Every yard plan (Drawings of the block) which the design is preparing in CSL will have an isometric view which shows the 3D coordinates (X,Y,Z values) Figure 1 shows the isometric view of a block .The coordinate values of the critical points will be indicated in the drawing if the additional points are required same can be collected from the design. The software in which CSL (Cochin shipyard yard) using is TRIBON its output is 2D Autocad drawing (Yard plan/Working drawing).
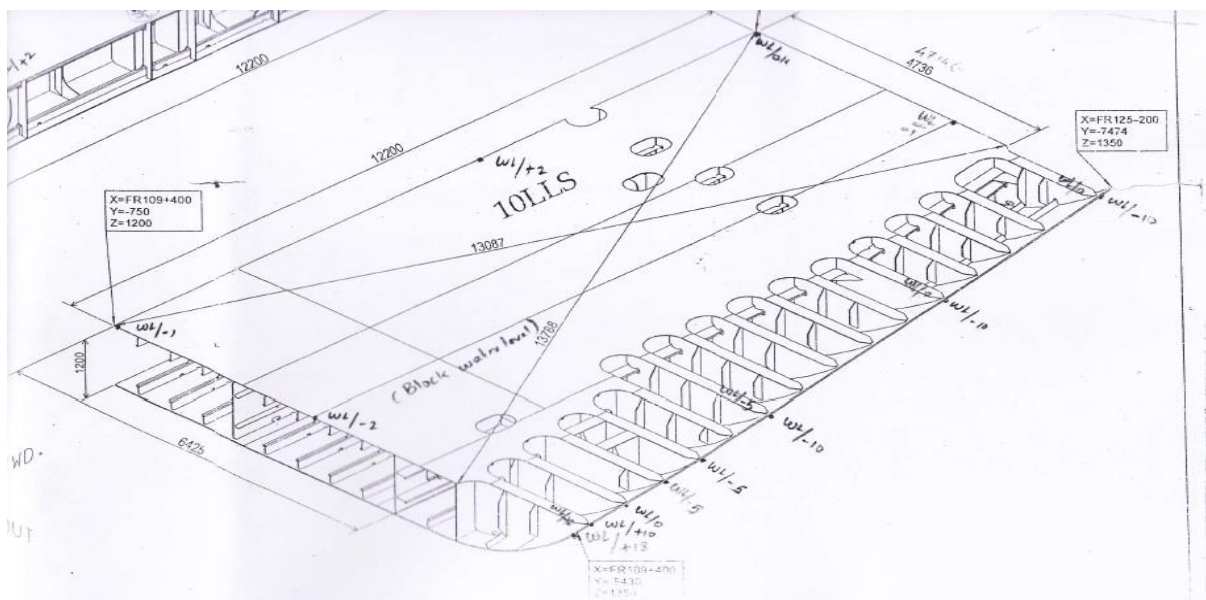

Fig 1:- 3D coordinates values of a block

A. Checking for the variation in the block
For checking the variation a design model is created in 3D AutoCAD, take the measurement using the total station import the dxf file to AutoCAD and create the model of the fabricated block and superimpose the same in the design

model and find the variation. This is done before starting of the welding so that if any correction is there same can be corrected. Figure 2 shows total station for taking the 3D measurement.

Fig 2:- Total station for taking the 3D measurement

The checking for the variation in the block has three stages they are as follows:

➢ **Stage 1**: Preparing the 3D model with a designed coordinate value in the AutoCAD. It consist of the following steps:

- Take the drawings of the corresponding block and enter the coordinate value of respective point (X,Y,Z).
- Using the excel function concatenate convert each points as point x1,y1,z1.,point x2,y2,z2,…..point x3,y3,z3.

- Select all points and paste the same in the command tab then every point will be imported to AUTOCAD.
- Connect the points using the straight lines and splielines.

➢ **Stage 2**: Preparing the 3D Model of the actual block using the measurement taken with the
   Total station (Electronic distance measuring equipment)

- Place the total station in the vicinity of the block where the measurements are to be taken.
- Place retro-reflector targets where the measurements are to be taken. Figure 3 shows blocks placed with retro reflector targets.
- Place temporary targets such that 3 Nos of temporary targets will be visible all the time.
- Temporary targets should be 6-8 Nos .It should be placed such that maximum numbers, more than (4 Nos) should be visible in the initial setting.
- Temporary targets are used when total stations are shift from one station to other, it is used to create same grid as the initial one (1st setting).
- Take xyz measurements of the points in the block with total station and temporary targets.
- Create the actual model in the AutoCAD.

Fig 3:- Blocks place with retro-reflector targets for taking measurement.

➢ **Stage 3**: Processing of Data
- Superimpose the model created using the total station and design model
- Find out the variation and correct the variation before starting of the welding.

B. Cutting of extra material before erecting the block

In conventional method extra material is being cut in the building dock after aligning the block in the dock. It is a very difficult process because the people have to go inside the confined space. So in this new method the extra material will be removed before the blocks are being placed in the dock.

Advance cutting of material consist of following steps:

➢ Preparing the 3D design model of individual block this activity is done in the Stage:1 for correcting of variation .

➢ Make the design 3D layout models by joining with the neighbouring blocks which are going to erect.

➢ Then prepare the actual 3D model which is done in the stage 2: for correcting the variation.

➢ Prepare the models with the actual models of the surrounding blocks indicated in the SL.no: 3 find out the material to be trimmed and trim the same.

➢ Carry out erection using dock mark.

III. LOGIC OF PROGRAM FOR CORRECTING THE INACCURACIES AND FOR CUTTING OF EXTRA MATERIAL OF BLOCKS

A. Methodology
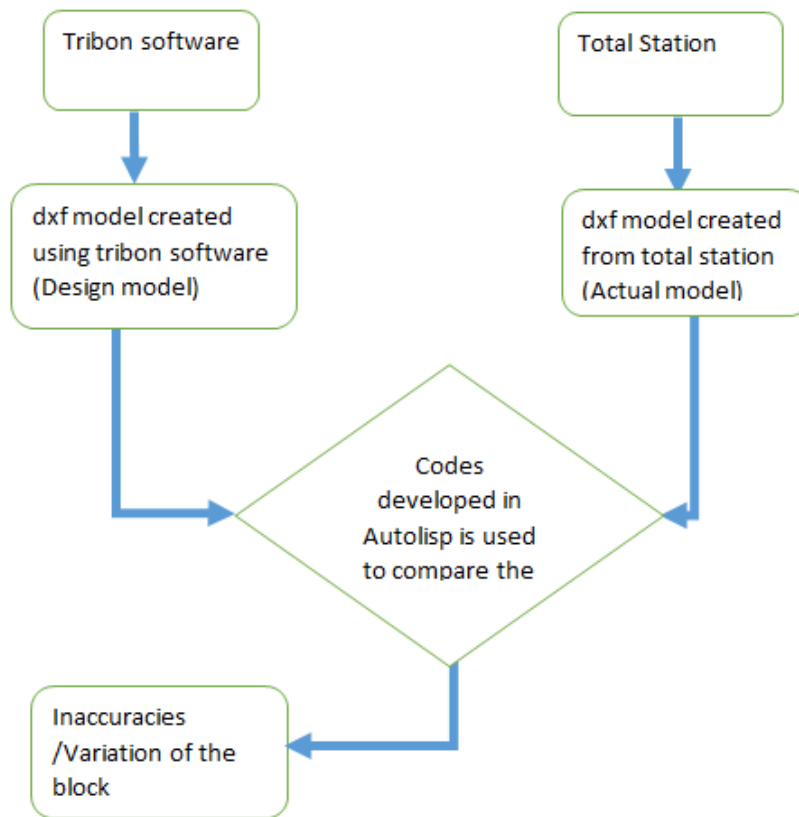
B. The method of comparing the inaccuracies of block is as follows:

➢ The design software the yard using is TRIBON, from the same design dxf model can be created or the coordinate value are entered in the excel and export to dxf format to make the design model. The table 1 shows the data to make the design model and the figure 4 shows the design model created from the data in the excel format

UNIT 3	AP1-3	22.75	6.75	3	POINT 22.75,6.75,3
UNIT 3	AP2-3	22.75	6.75	1	POINT 22.75,6.75,1
UNIT 3	AP3-3	22.75	4.95	0	POINT 22.75,4.95,0
UNIT 3	AS3-3	22.75	-4.95	0	POINT 22.75,-4.95,0
UNIT 3	AS2-3	22.75	-6.75	1	POINT 22.75,-6.75,1
UNIT 3	AS1-3	22.75	-6.75	3	POINT 22.75,-6.75,3
UNIT 3	ATP	22.75	0.59	3.06	POINT 22.75,0.59,3.06
UNIT 3	ATS	22.75	-0.59	3.06	POINT 22.75,-0.59,3.06
UNIT 3	FP1-3	33.25	6.75	3	POINT 33.25,6.75,3
UNIT 3	FP2-3	33.25	6.75	1	POINT 33.25,6.75,1
UNIT 3	FP3-3	33.25	4.95	0	POINT 33.25,4.95,0
UNIT 3	FS3-3	33.25	-4.95	0	POINT 33.25,-4.95,0
UNIT 3	FS2-3	33.25	-6.75	1	POINT 33.25,-6.75,1
UNIT 3	FS1-3	33.25	-6.75	3	POINT 33.25,-6.75,3
UNIT 3	FTP	33.25	0.59	3.06	POINT 33.25,0.59,3.06
UNIT 3	FTS	33.25	-0.59	3.06	POINT 33.25,-0.59,3.06

Table 1:- Design coordinate value of unit 3 of the BY-106
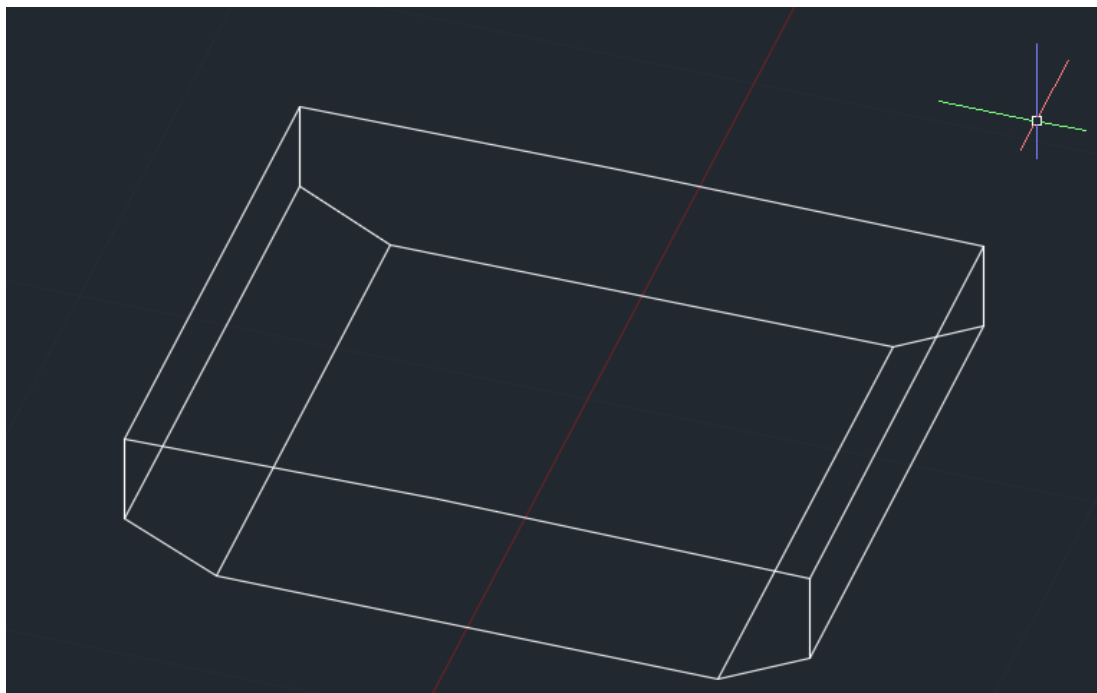
Fig 4:- Design model of the Unit 3 of the BY-106

➢ The block is measured using the Total station Figure 5 shows a personal taking the measurement of unit 1 of the BY-106 and a
  Cloud point data of the actual model is generated see figure 6. The cloud point data is then processed using the Autocad and
  the actual design model is created see figure7.

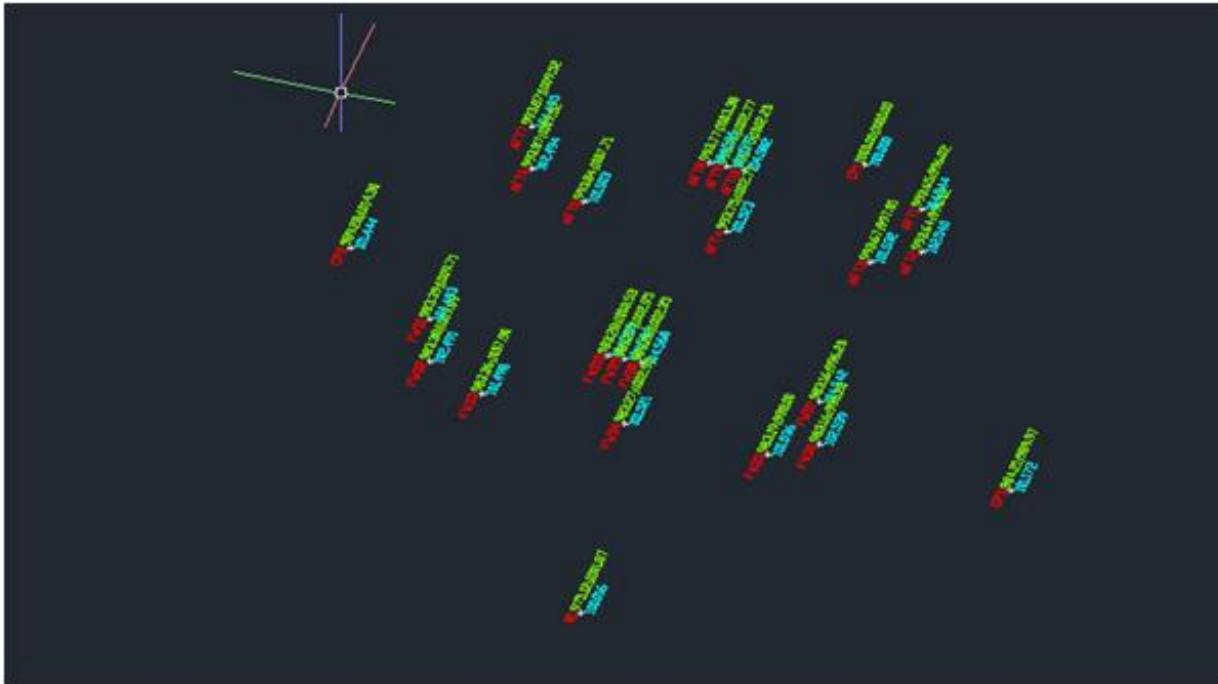Fig 5:- Personal taking measurement of the Unit 1 of the BY-106

Fig 6:- Cloud point data from the total station of the unit 3 of BY-106.
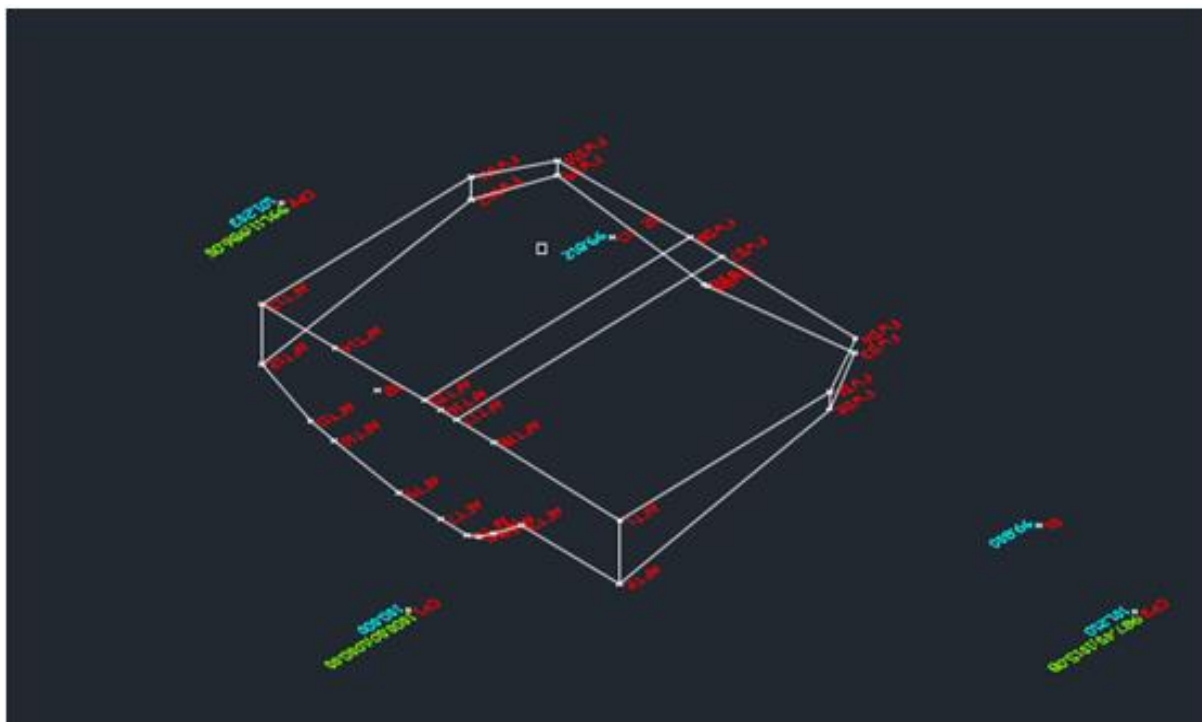
Fig 7:- Model developed from the Total station (Unit 1 of the BY-106)

➢ The design model and actual model is compared using the program created using Auto lisp. The program is so created that it is capable of giving the delta value i.e it can give the variation, if the variations are within the standard same is accepted otherwise the same will be rectified.

IV. CODING TO FIND THE INACCURACY AND FOR CUTTING EXTRA MATERIAL IN BLOCKS.

A. Type and Requirement of coding

One of the disadvantage of using 3D Auto CAD and dxf data from Total station is that the best fit is not possible. So it is decided to develop a program using the Auto lisp so that the best fit can be carried out using single point. The method is as follows, the point which require to compare with the design and actual model (developed from

the Total station) are so aligned that a three mutually perpendicular line is fitted in the point which need to be compare, it is done in such a way that such that the X axis will along the longitudinal and will be parallel to the deck then the intersecting point of the three mutually perpendicular lines will be on the erection butt where extra material was not available, the same will be done on the design and actual block which are to be aligned. The coding is also done in such a way that it is capable of giving the delta value that is the difference between the design and actual.

B. Codes developed for checking the inaccuracies and for cutting the extra is as follows:

➤ *The method of selecting the program:*

The codes are developed using the program Autolisp and the same is saved in a drive. The method of correcting the inaccuracies is as follows create a file in which both the design and actual blocks are saved, for that the design 3D model are created by importing data from excel to dxf and the actual 3D models are developed from the data obtained from the total station (Cloud point data) for the respective block. The figure 8 shows the design model (Green) and the actual block (Red) and the method to select the program to the required file. The blocks are given the green and red colour to correlate with each block so that the difference between the point of interest of the actual blocks and the design blocks should be able to compare easily without any difficulty.
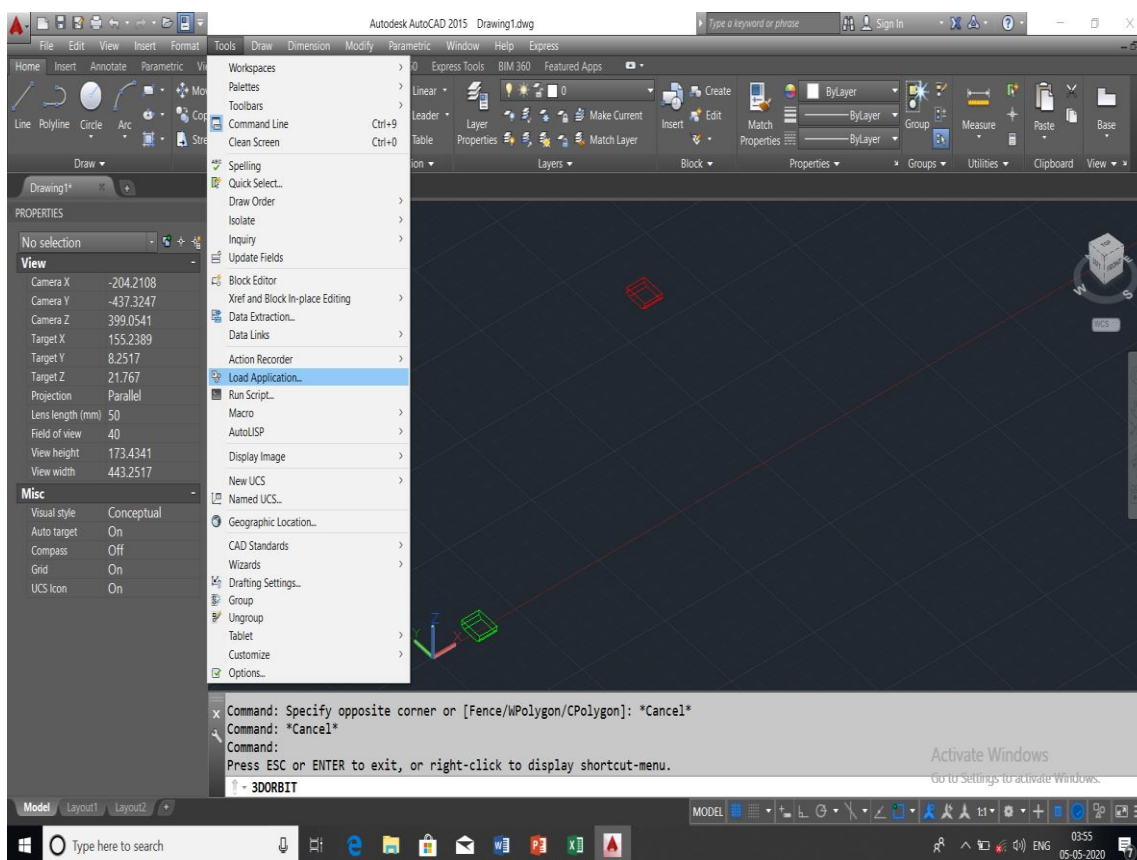
Fig 8:- The method to load the application

➤ *The method for checking the inaccuracies of the block*
- Load the program 2-R and close the same .The figure 9 shows how to load the application on to the file.
- After the program has been loaded successfully input aa in the command bar and enter. See the figure 10.
- The program will ask to input four points in the actual blocks it is selected in suck a way that first two points are selected from the butt joints of the blocks where no extra material are available see figure 11 and figure 12.
- The program will ask to input four points in the design blocks it is selected in such a way that first two points are selected from the butt joints of the blocks where no extra material are available see figure 13, and it should be selected in the same sequence as selected in the SL.NO:3
- The program will ask to input the block in which the first four points are selected see the figure 14
- The program will ask to input the block in which the second four points are selected see the figure15
- The program will ask to input Y/N, if Y the program will align the block, and N vice versa
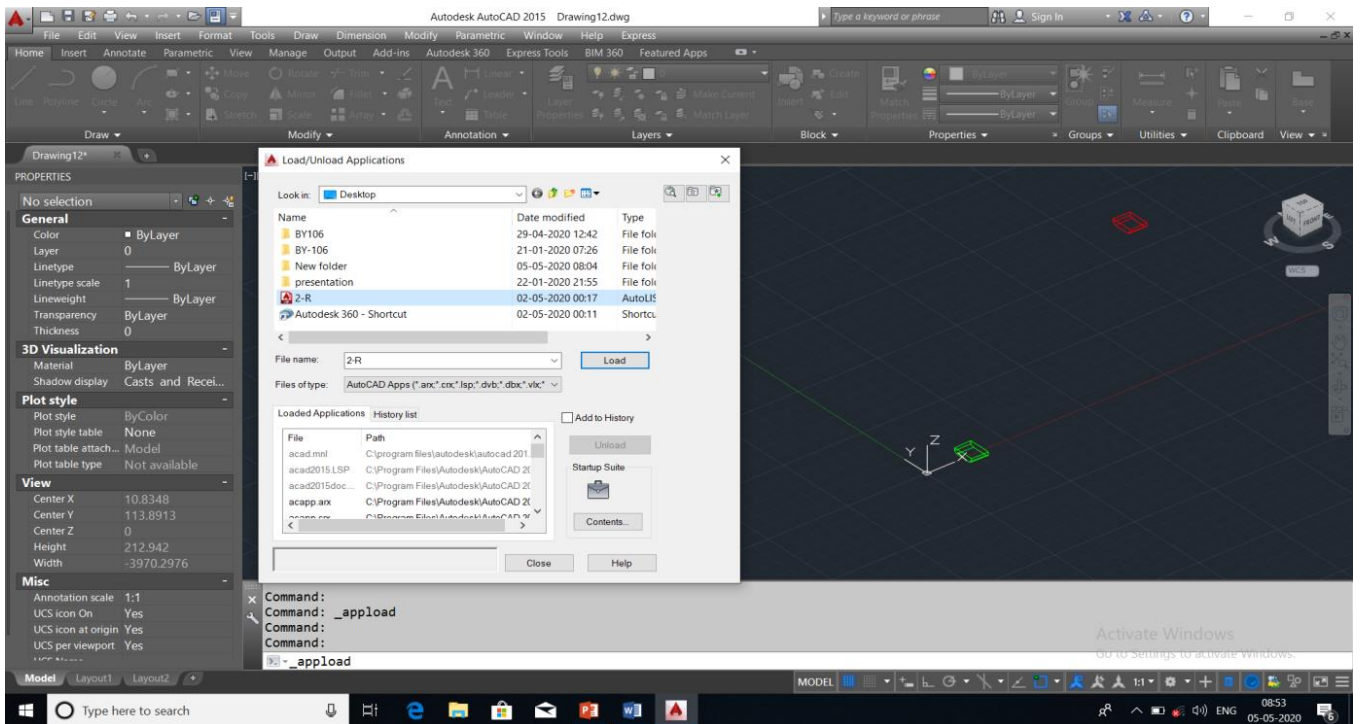
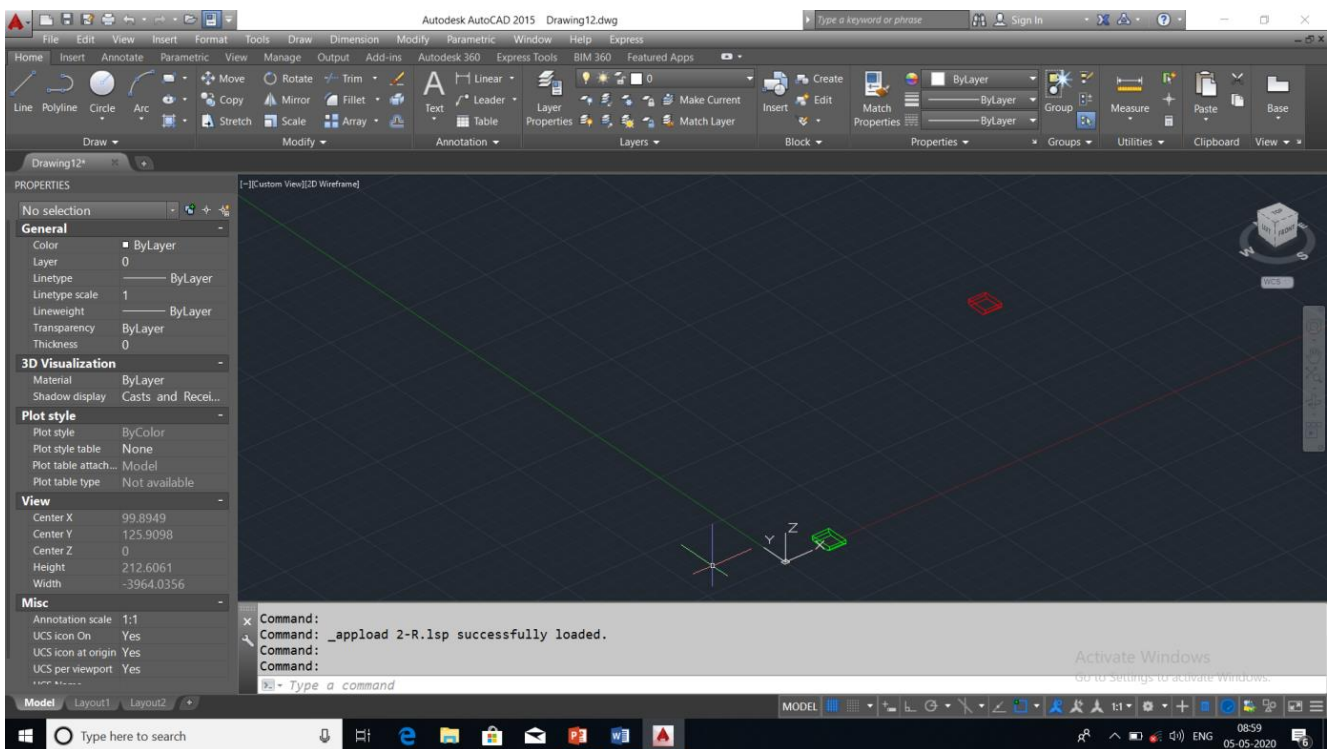Fig 9:- Loading the program to the file

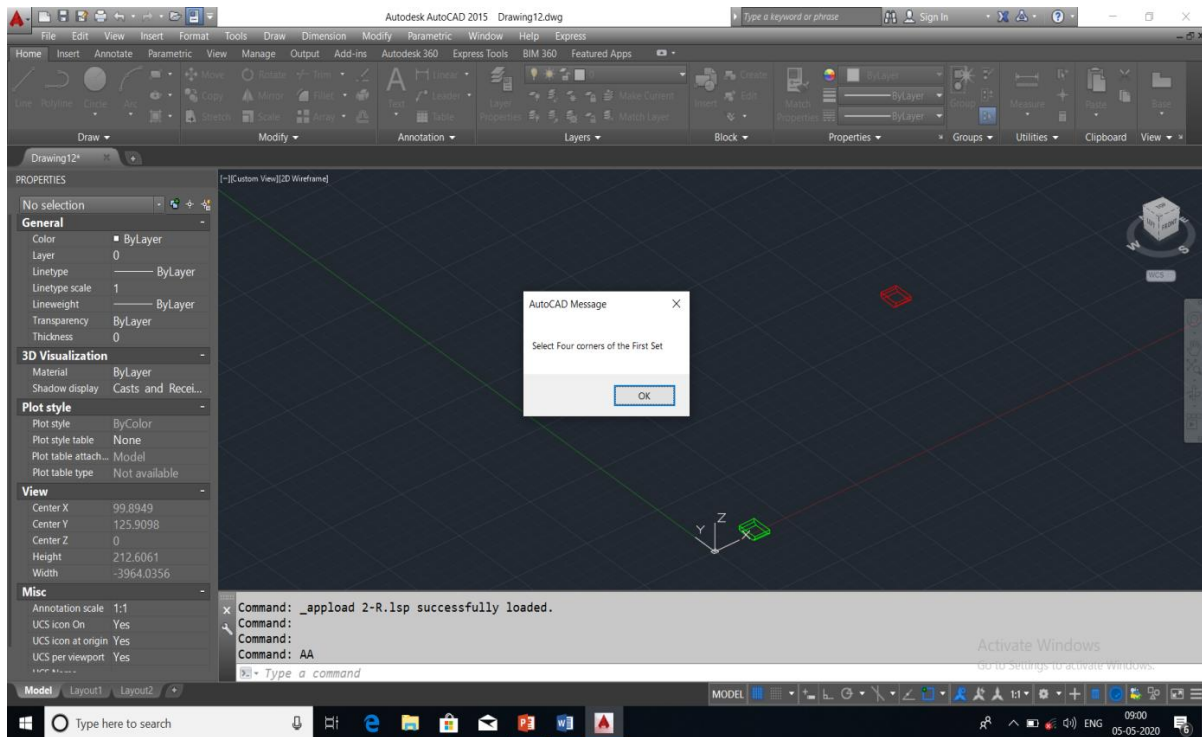Fig 10:- Input data to load the application

Fig 11:- Shows the method of selecting the four point of the actual model (Red)-First set
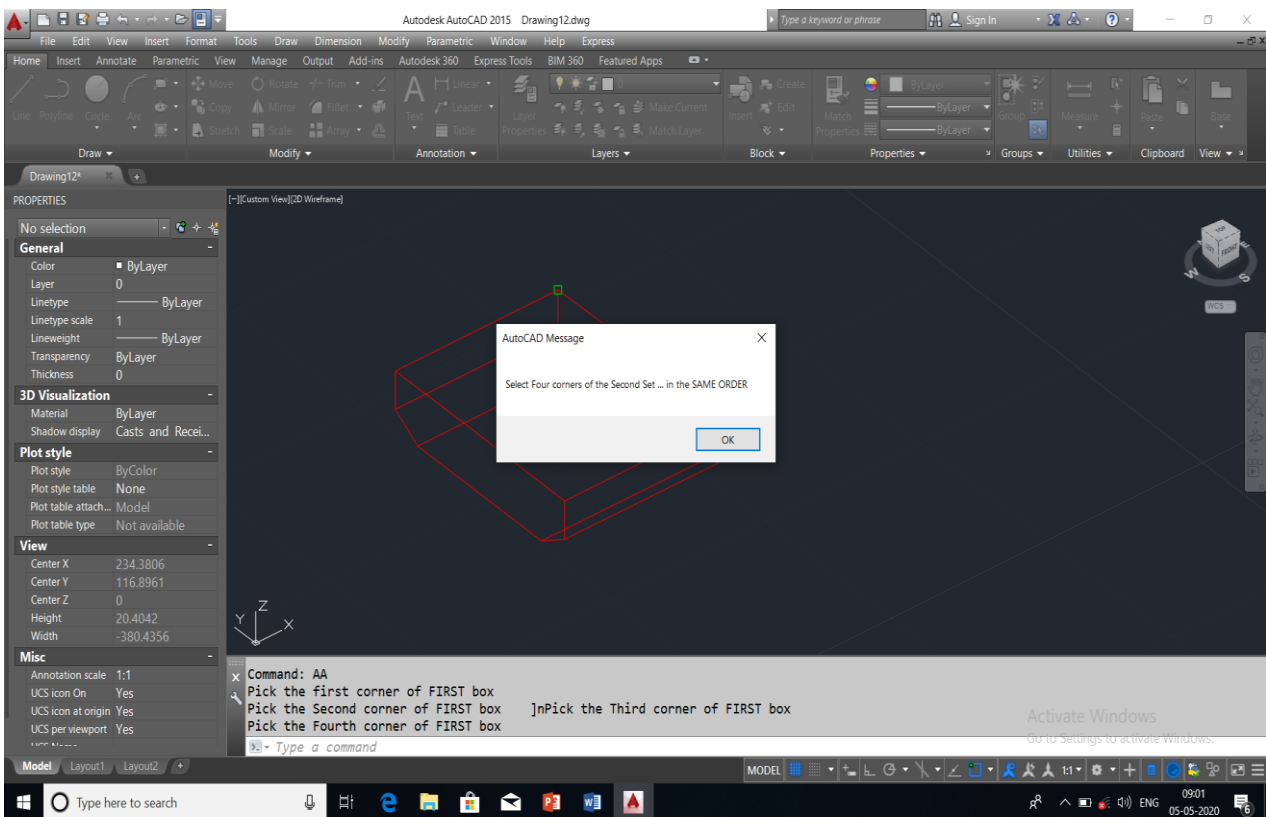

Fig 12:- Shows the method of selecting the four point of the actual model (Red)
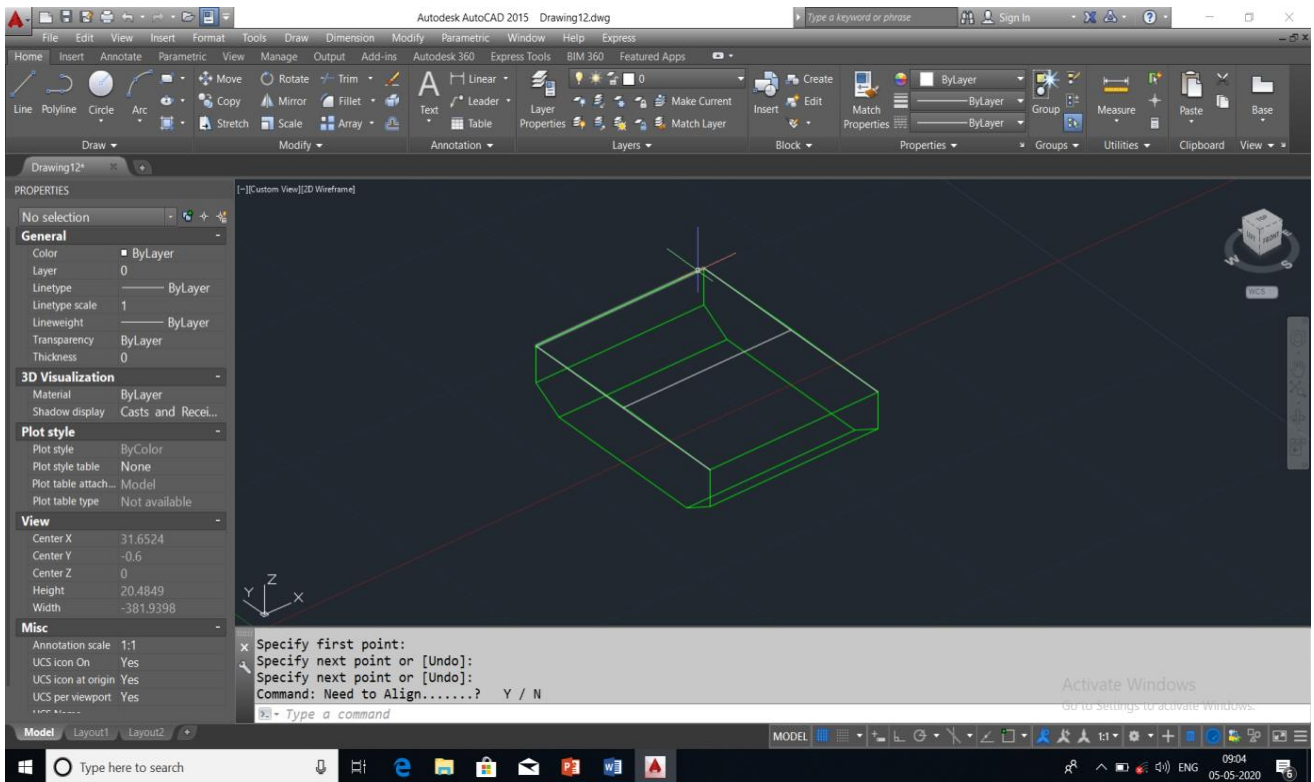
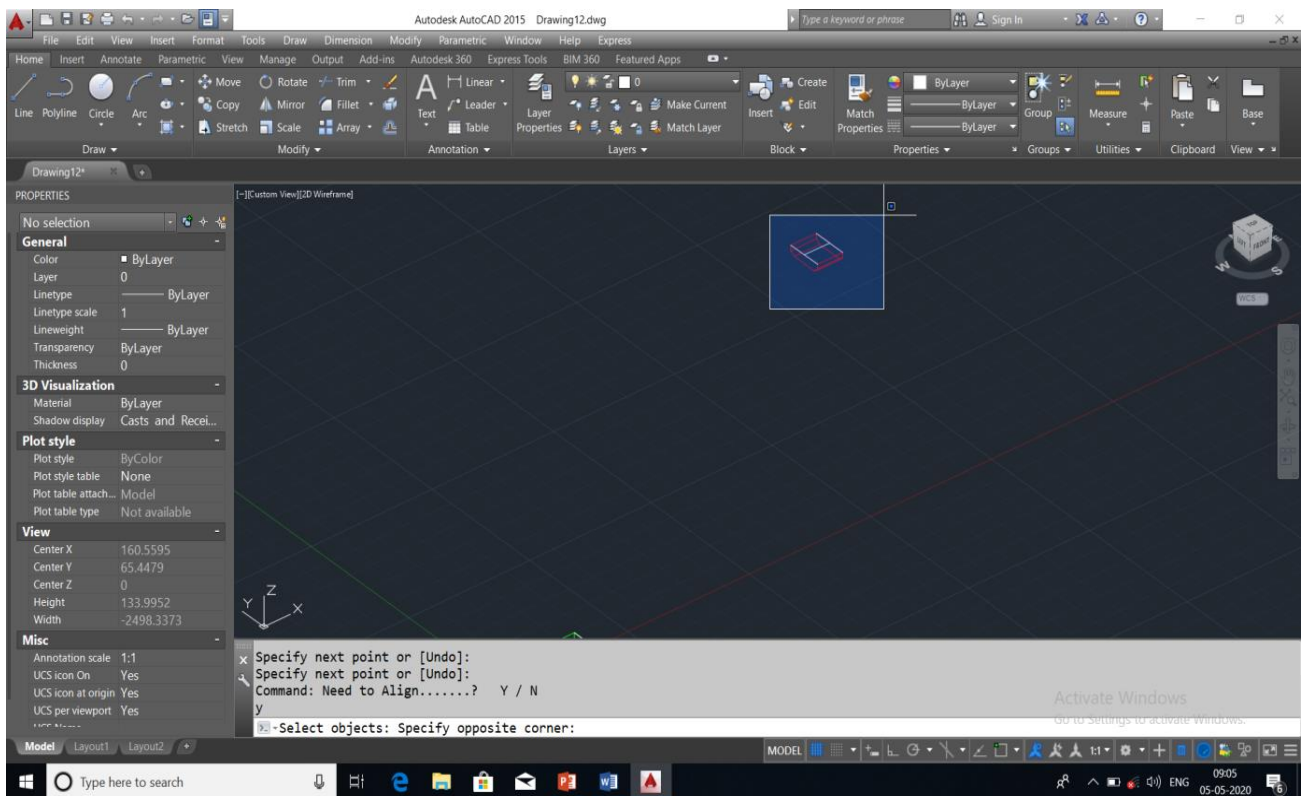Fig 13:- Shows the method of selecting the four point of the design model (Green)

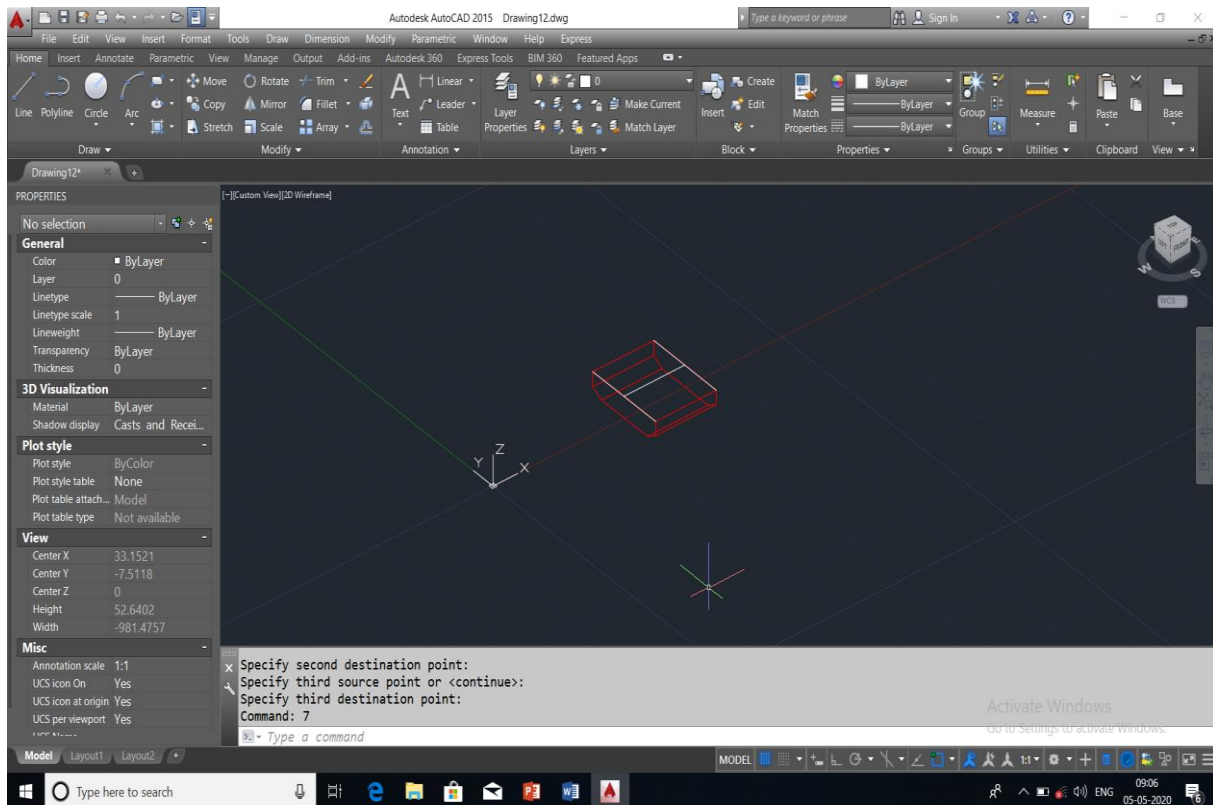Fig 14:- Shows the method of selecting the actual model (Red)

Fig 15:- Shows the method of selecting the design model (Green)

➢ *The method of finding the deviation between design and actual model*
- After the block has been aligned input bb in the command bar see the figure34
- The program will ask to pick the first point see the figure 35
- The program will ask to pick the second point see the figure 36
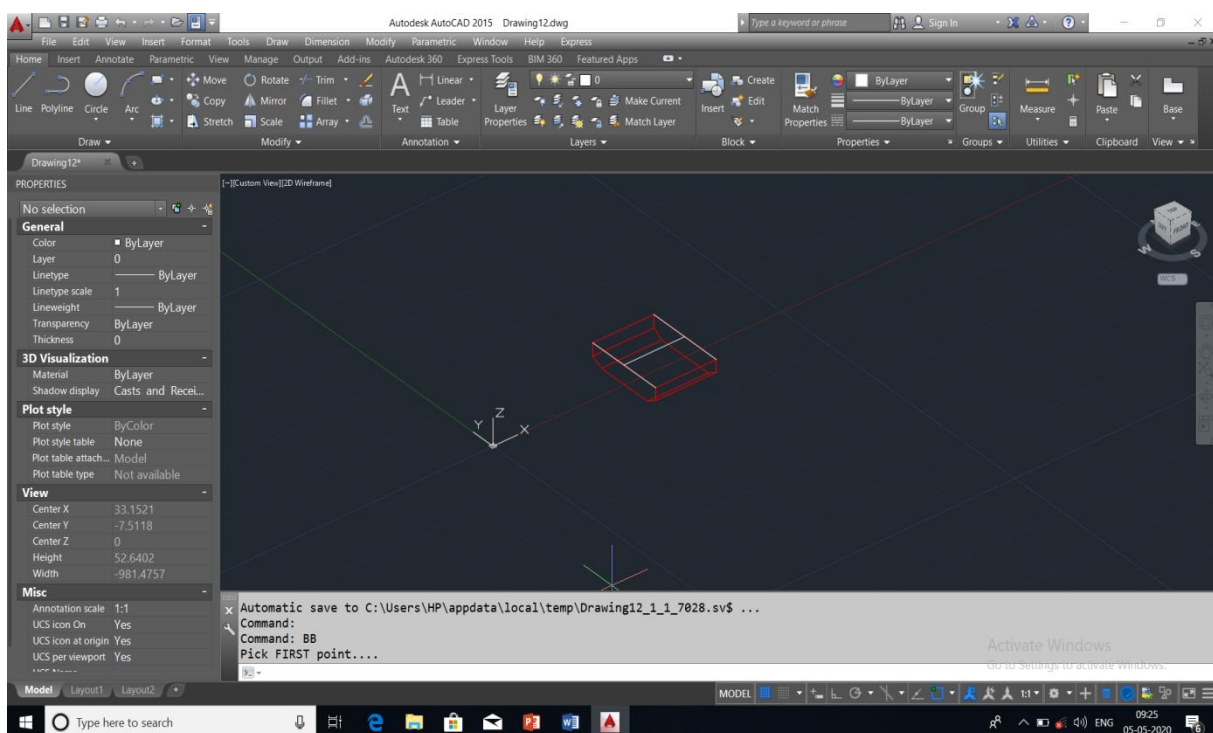- The program will ask for text height enter the same as 1 then the output of the program will be the difference in x,y and z coordinate see the figure37

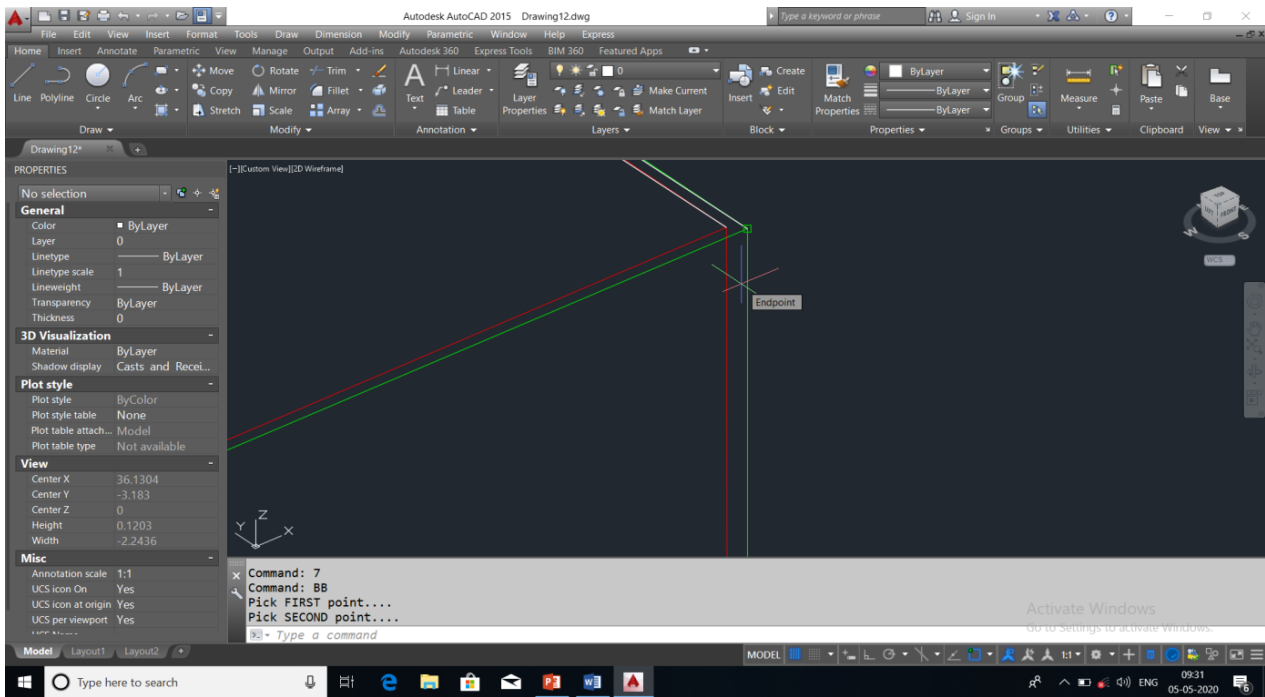Fig 16:- Input command for finding the deviation of a point

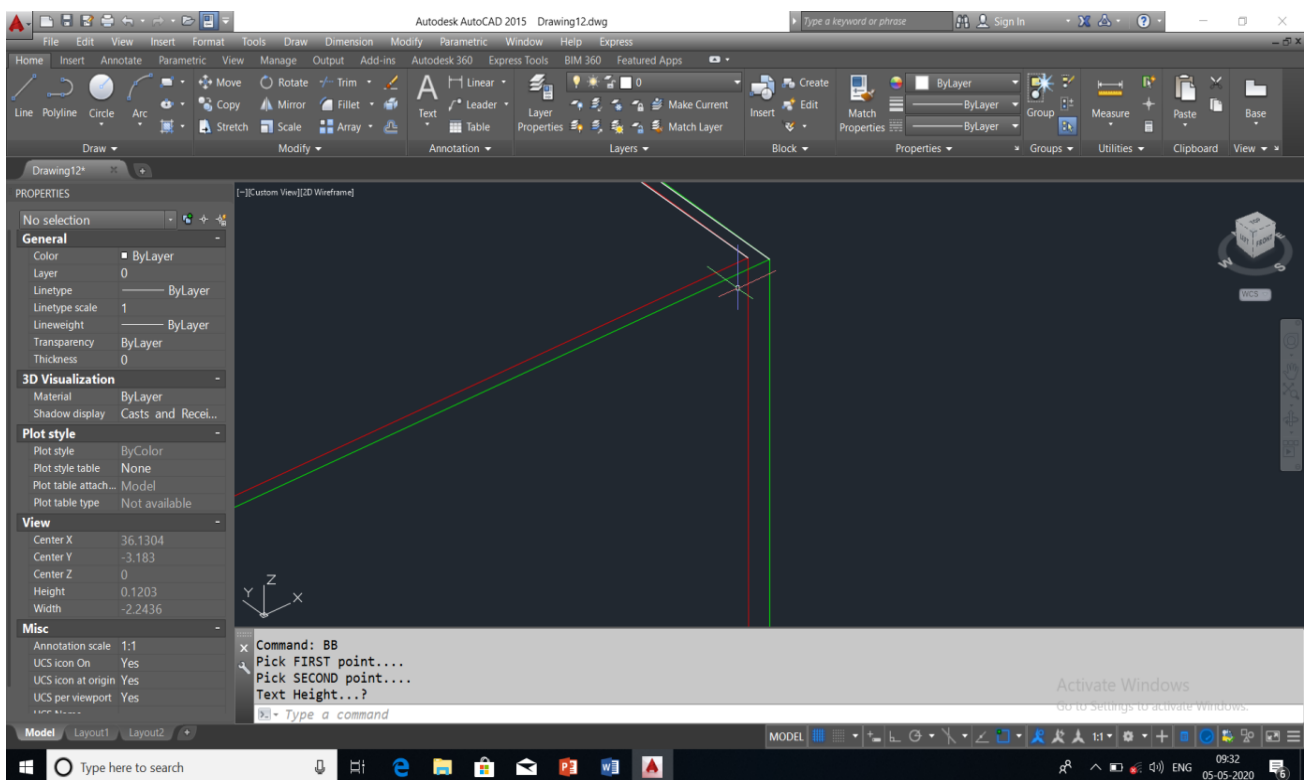Fig 17:- Selecting the first point of the design model (Green)

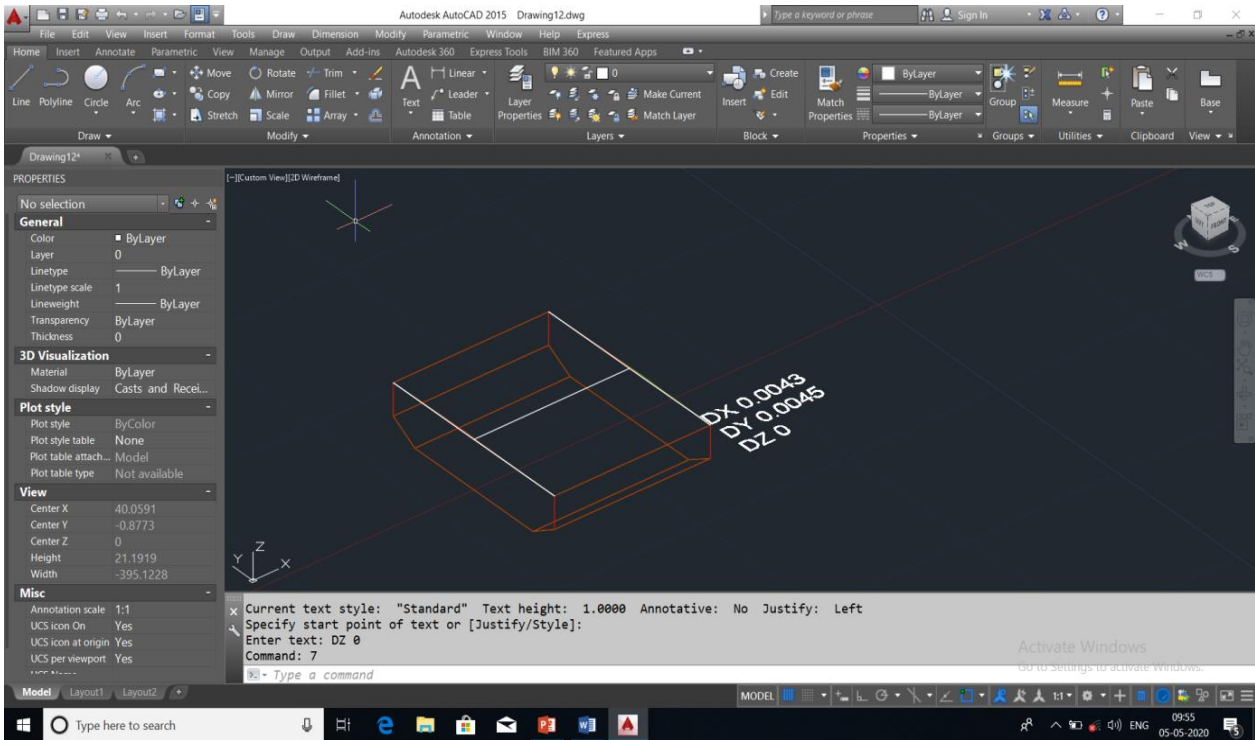Fig 18:- Selecting the Second point of the actual model (Red)

Fig 19:- Deviation of the x,y and z Coordinate

V. TESTING OF PROGRAM TO FIND THE CAPABILITY ON THE VESSEL RO-RO

The vessel selected for the testing of the program was a Roll on- Roll off vessel being built for the Ganga water project. The testing was done on five main units of the vessel .There was two vessels BY-105 and BY-106 being constructing in the yard, the experiment was carried out on BY-106, and the BY-105 was constructed in the conventional way. Since the two vessel are constructed in two different method so that the cycle time for the erection are being evaluated.

A. Checking of the inaccuracies in the units of the vessel By-106
➤ *Design model of the Unit 1~5 of the vessel BY-106*

The dxf design model can be created by using Tribon software which is being used by the yard or by exporting the coordinate value from the excel to dxf see figure 20.
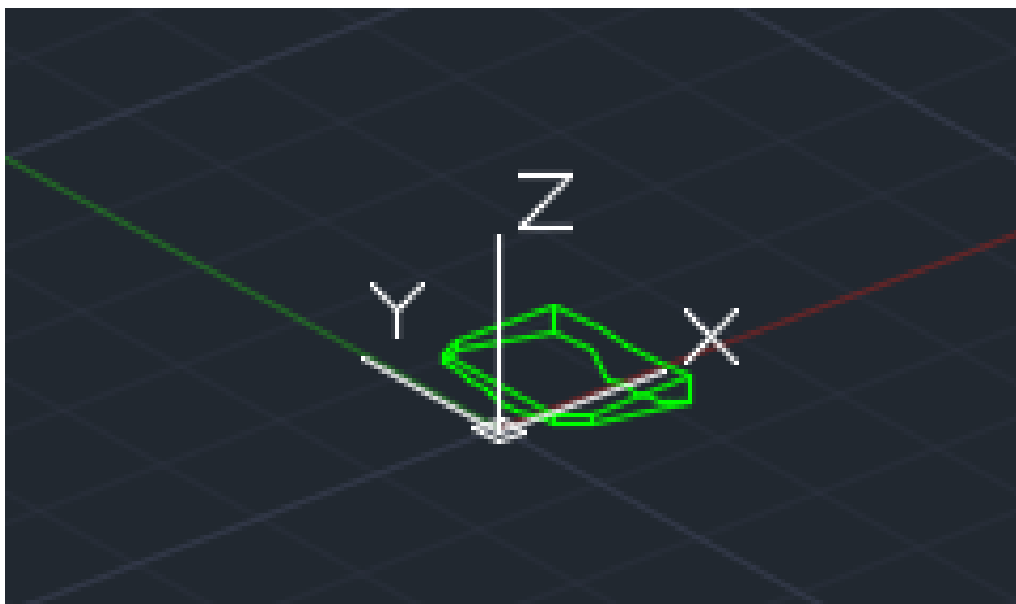

Fig 20:- Design model of Unit 1 of BY 106 (Green for Design model)

➢ *Actual model of the Unit 1~5 of the vessel BY-106 developed from Total station*
- The actual dxf model can be created by using the data obtained from the total station.
- Initially a cloud point data is created as an output from total station.
- From the cloud point data actual dxf design model can be generated using the help of splines/lines see figure 21
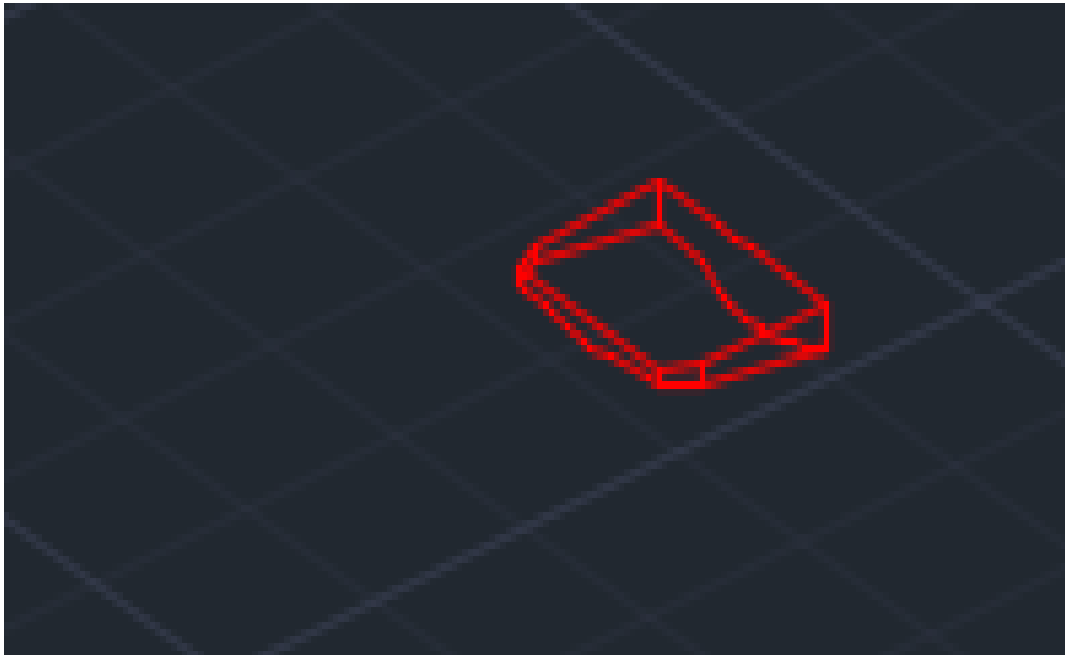

Fig 21:- Actual model developed from the total station dxf data (Red for actual model)

➢ *Using the program the actual and design model are being compared as follows:*
- Design model is saved in a file
- The cloud point data from the total station is saved in the same file
- The actual model is developed from the cloud point data
- The Three mutually perpendicular lines are fitted in the similar points on the actual and design model (Usually on the midpoint of the erection butt)
- Aligned the same point
- Find the difference in one dimension (figure 22) and delta value (difference of x, y and z coordinate) figure 23.
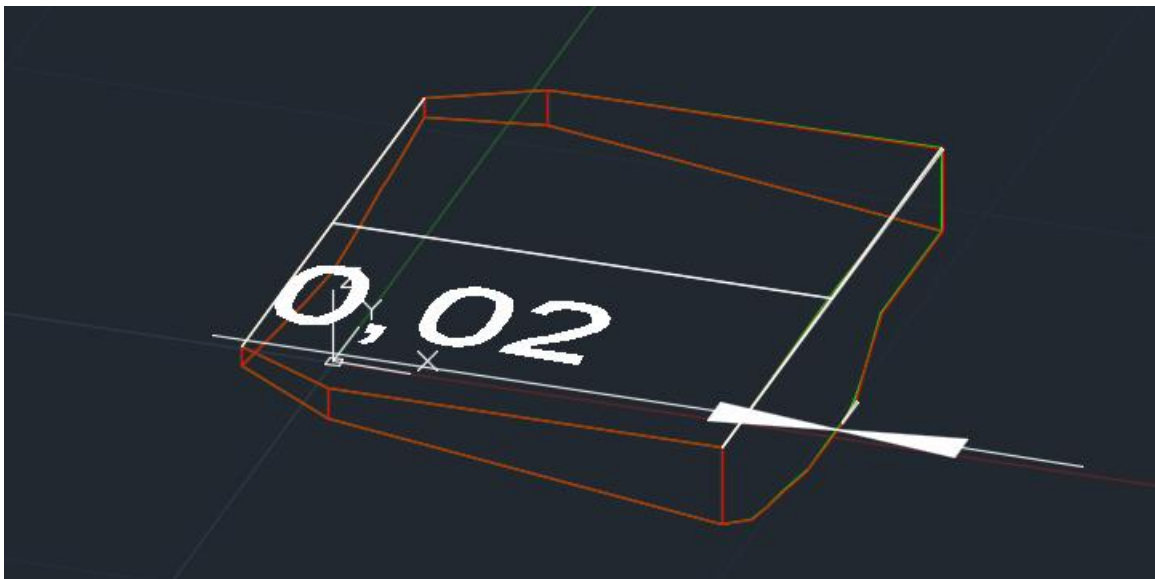

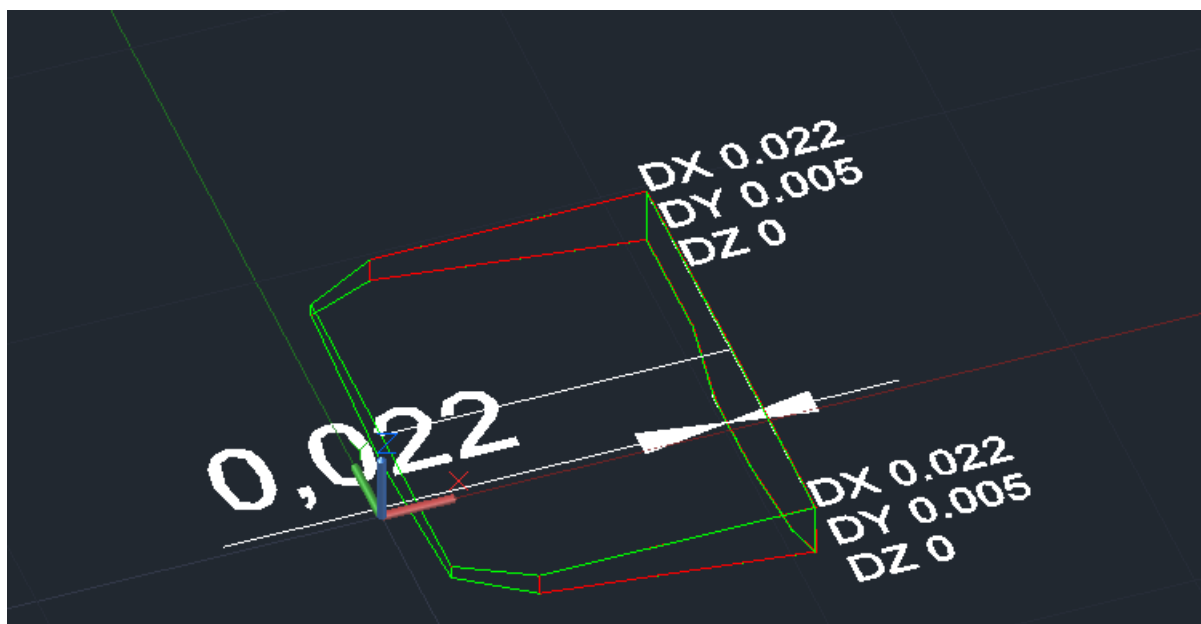Fig 22:- Difference in one dimension of Unit 1

Fig 23:- In accuracies of Unit 1 with difference in x, y and z coordinate

Variations in dimensions of the units 1~5 with the design and actual model has been listed in the Table 2 along with the tolerance value to be maintained is as follows:

See appendix to find the dimensional value achieved for units 1~5. See Figure 24 to 28 to find the inaccuracies of the block with design and actual block

DIMENSIONS OF UNIT1~5 OF THE VESSEL BY-106								
		VARIATION IN mm			TOLERANCE VALUE			Extra material to be trimmed (mm)
UNIT	LOCATION	DX	DY	DZ	DX	DY	DZ	
Unit1	AP	0	0	0	8/6	6.75	3	Erection butt
Unit1	AS	0	0	0	8/6	6.75	3	Erection butt
Unit1	FP	22	5	0	8/6	6.75	3	22
Unit1	FS	22	5	0	8/6	6.75	3	22
Unit2	AP	0.3	5	0	8/6	6.75	3	Erection butt
Unit2	AS	0.3	5	0	8/6	6.75	3	Erection butt
Unit2	FP	22.3	3.5	0	8/6	6.75	3	22.3
Unit2	FS	17.7	3.5	0	8/6	6.75	3	17.7
Unit 3	AP	0.6	3.5	0	8/6	6.75	3	Erection butt
Unit 3	AS	0.6	3.5	0	8/6	6.75	3	Erection butt
Unit 3	FP	4.6	4.5	0	8/6	6.75	3	weldable gap
Unit 3	FS	3.5	4.5	0	8/6	6.75	3	weldable gap
Unit4	AP	28.5	4	0	8/6	6.75	3	28.5
Unit4	AS	27.5	4	0	8/6	6.75	3	27.5

Unit4	FP	0.5	5	0	8/6	6.75	3	Erection butt
Unit4	FS	0.5	5	0	8/6	6.75	3	Erection butt
Unit5	AP	22	-5	0	8/6	6.75	3	22
Unit5	AS	22	-5	0	8/6	6.75	3	22
Unit5	FP	0	0	0	8/6	6.75	3	Erection butt
Unit5	FS	0	0	0	8/6	6.75	3	Erection butt

Table 2:- The list of dimensional value achieved for Unit 1~5 for the vessel BY-106

VI. CONCLUSION

The dimensional control of the block which was carried out using the manual method is using the tapes so that all the measurement carried out are only 2D measurement hence it was unable to check the 3D measurement, this s because there are lot of partition bulkheads available in a block which make the task of 3D measurement tedious. Since the 3D measurement was not able to check using the tape, accuracy of the block was not been able to maintain hence which created lot of rework in the subsequent stages of the shipbuilding. When decided to carry out 3D measurement using the Total station and AUTOCAD the best fit of the design and actual model was not able to achieve. Hence it is decided to create a program for checking the accuracy of the block.

The method which developed for checking the block accuracy has many advantages since the codes are being developed can substitute many of the AUTO CAD commands are not required to be used hence the block dimensional check can be easily carried out. Since the codes are developed in Autolisp which support the AUTOCAD hence it is very user friendly. Unlike AUTOCAD the codes are so developed that the best fit with design model and actual model is possible which is not possible in using only AUTOCAD. The program developed is capable that the variation of the block can be visualized. The test program developed has been done in the five units of the vessel RO-RO and the block was able to manufacture well within the standard stipulate by the IACS-47[2]. The another achievement of using this methodology is that quality of weld joints are increased because the uneven gap which may occur during the course of construction are being minimized and the edge preparation are being carried out in open spaces unlike which has been carried out in the dock in the confined spaces. Since the blocks are manufactured to near net shape lot of rework due to inaccuracies are reduced to great extent hence the cost of rework are reduced to great extent.

APPENDIX
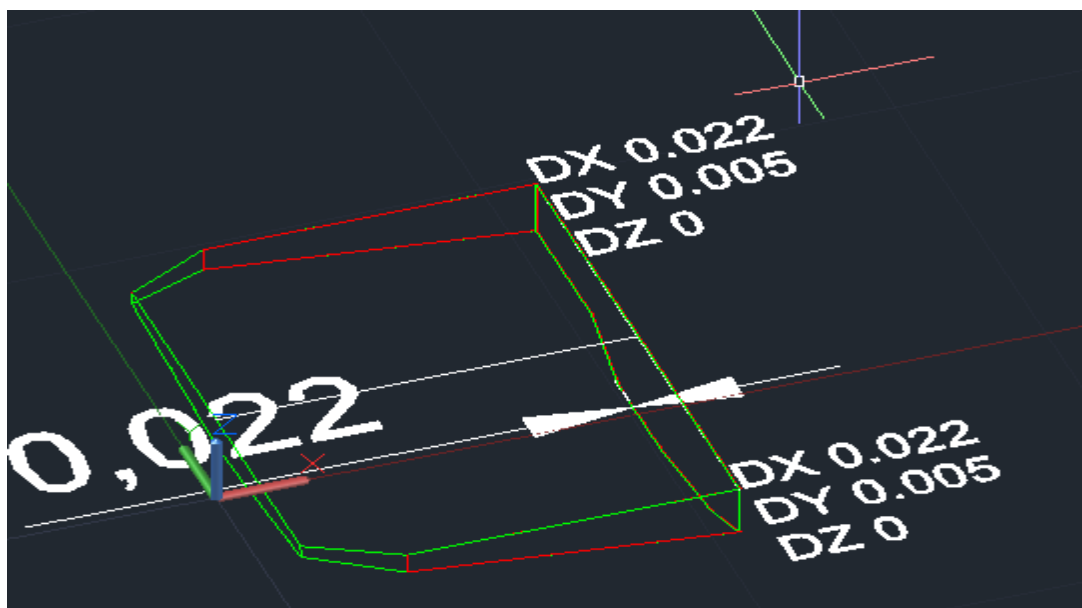**DIMENSIONS ACHIEVED FOR UNIT1~5 OF THE VESSEL BY-106**

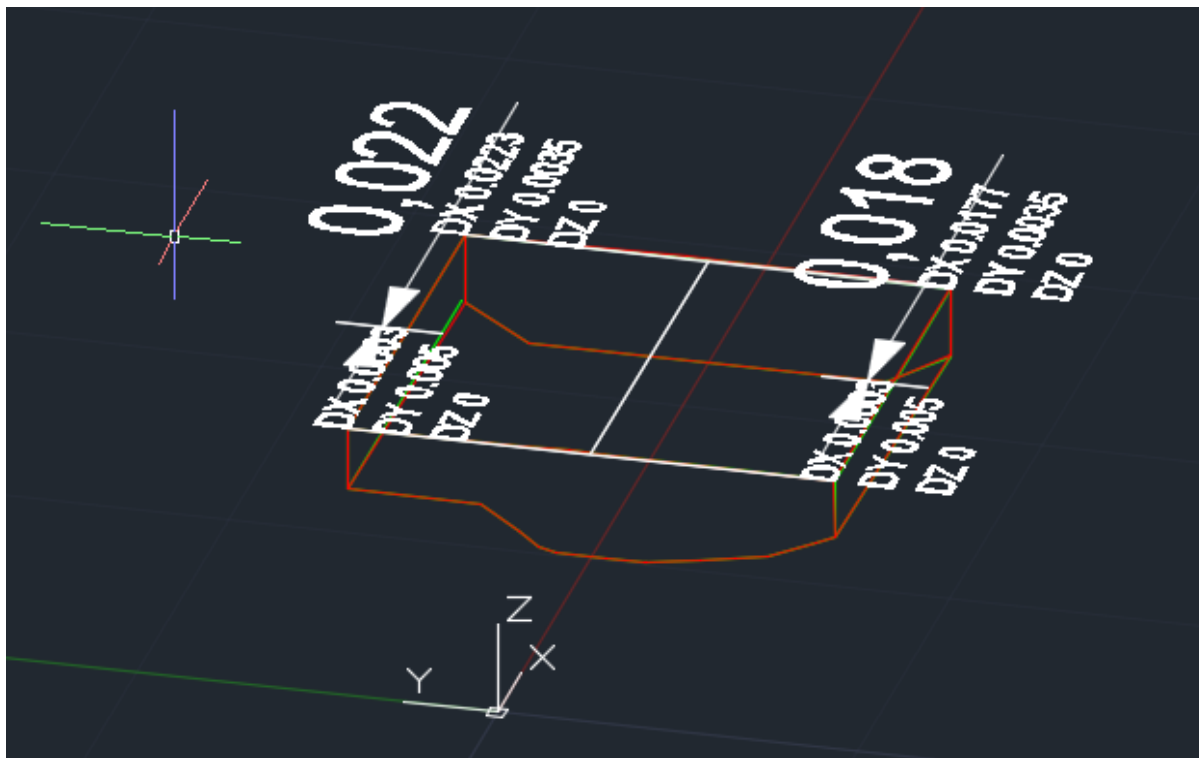Fig 24:- Variation of the unit 1 with the design model and actual model in the x, y, z coordinate

Fig 25:- Variation of the unit 2 with the design model and actual model in the x, y, z coordinate
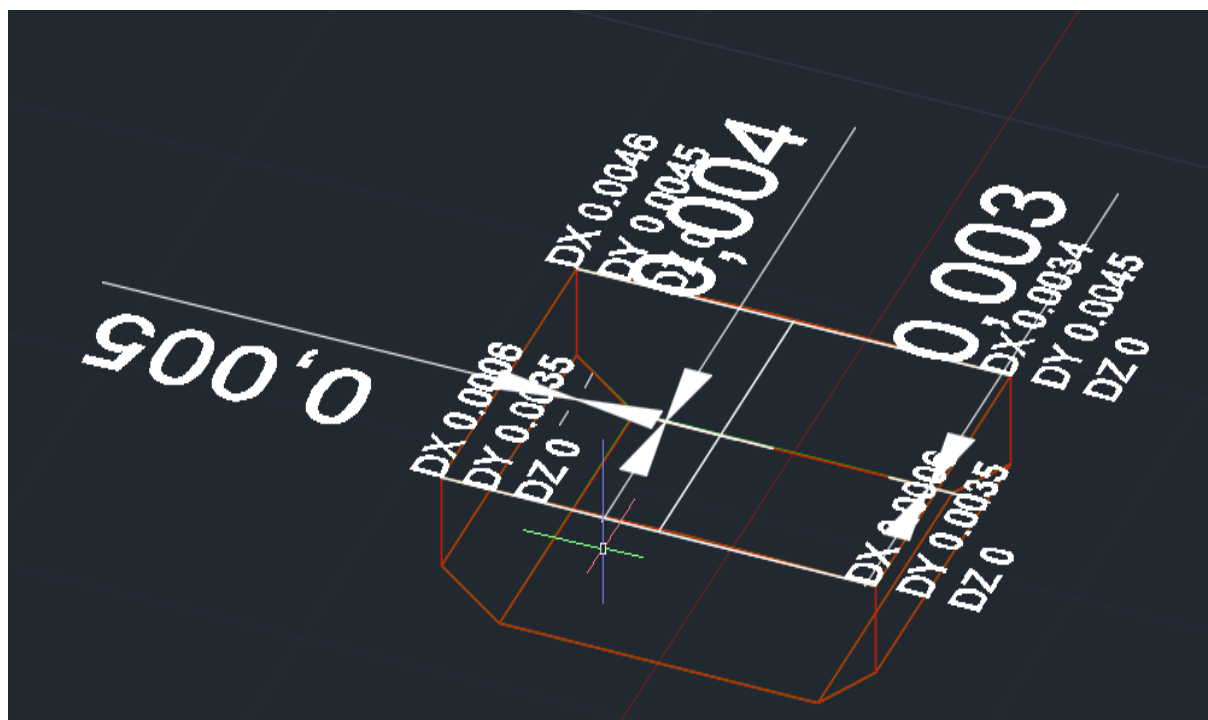

Fig 26: Variation of the unit 3 with the design model and actual model in the x, y, z coordinate
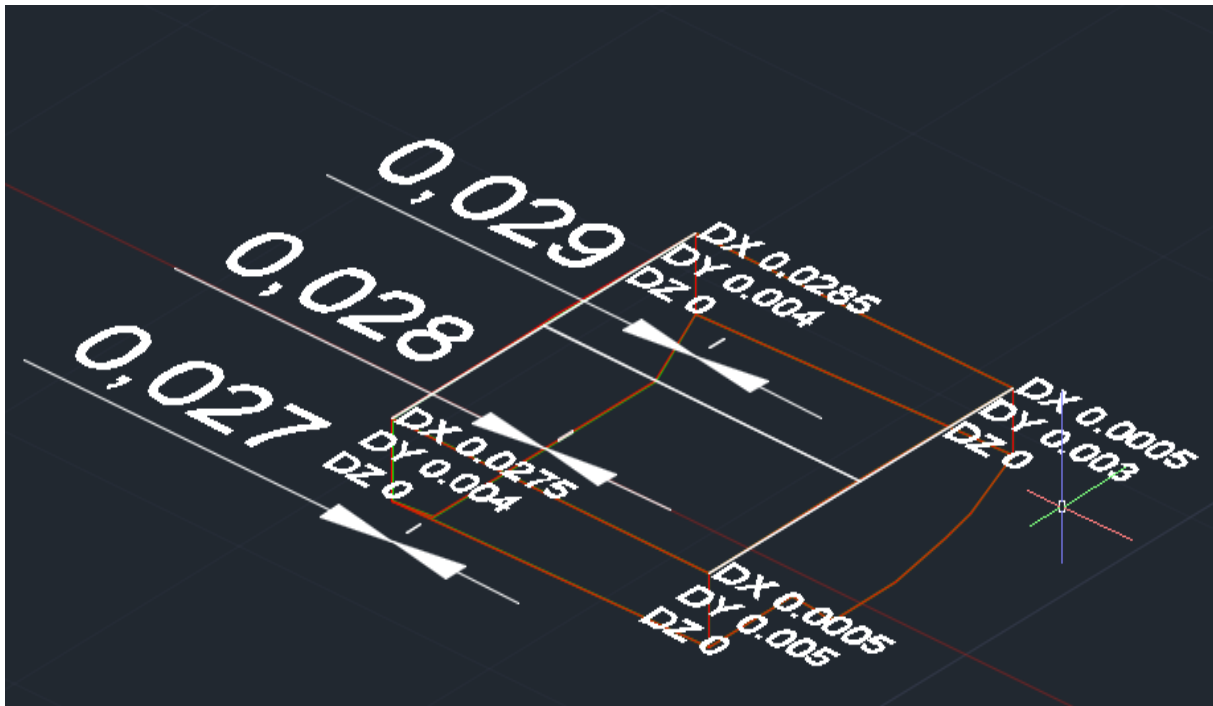
Fig 27:- Variation of the unit 4 with the design model and actual model in the x, y, z coordinate
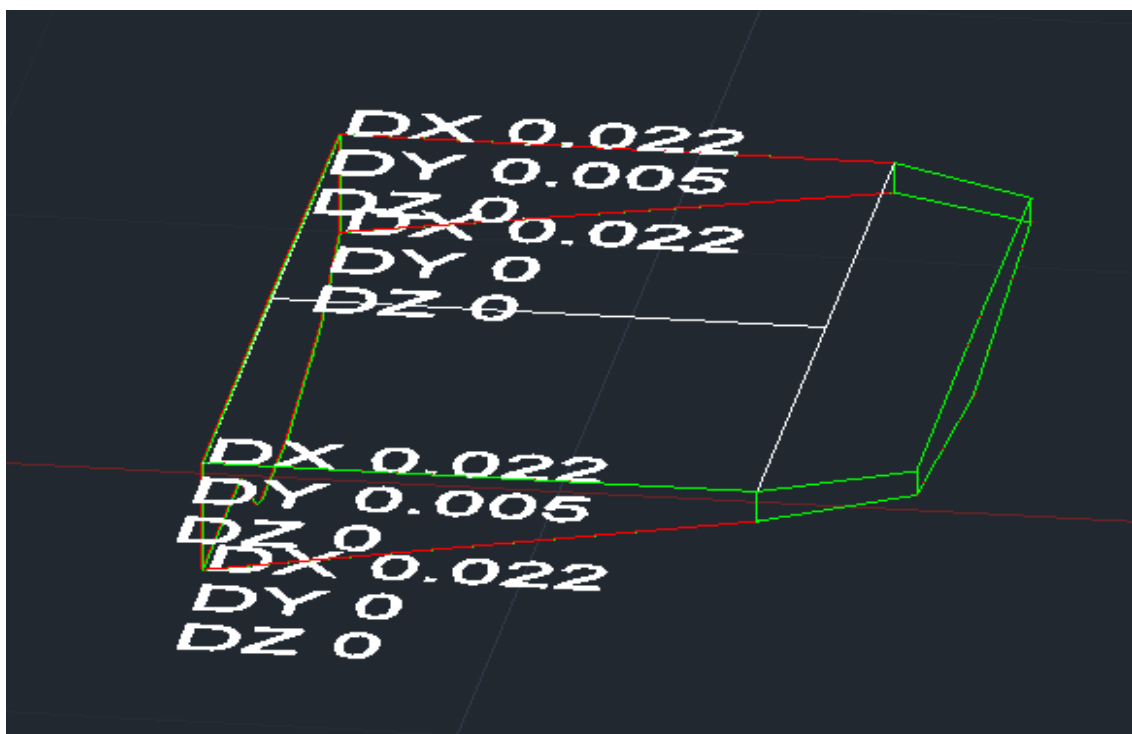

Fig 28:- Variation of the unit 5 with the design model and actual model in the x, y, z coordinate

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