Design and Analysis of a Portable Concrete Mixer

Arjun Desai[1], Harsh Bhutani[2], Abhishek Chavan[3], Atharva Chitnis[4], Dharmesh Chowdhary[5]

[1-5]*Department of Mechanical Engineering, Vishwakarma Institute of Technology, Pune-48, Maharashtra, India*

Abstract - *Concrete is one of the most important materials used in construction. It is one the most frequently used building materials. It is used worldwide and is almost used twice more than that of steel, wood, plastics, or any other metals combined. The ready-mix concrete industry is projected to cross 600 billion dollars in revenue by 2025. Due to this large scale and continuous requirement of concrete, the concrete mixer has become one of the most important machines on construction sites. It homogeneously combines water, sand or gravel used as aggregate and cement, to form concrete. Any concrete mixer uses a type of a drum to mix the components. A portable concrete mixer often is considered for small volume works or projects. It gives the workers enough time to mix and use the concrete before it hardens. In this project a portable concrete mixer has been designed and safety of the design has been verified by carrying out the analysis by giving specific boundary conditions and observing the deformation of each part.*

***Key Words*: concrete mixer, construction, portability, analysis, deformation**

1. INTRODUCTION

Concrete is prepared by mixing cement, water and various aggregates (mainly sand and gravel). It is very important to carefully select the proportions in which each component is used to make the concrete. This also defines the quality or grade of the concrete that is going to be formed. The main objective of this project was to design a concrete mixer, which is portable and can mix the components properly. Various calculations are carried out based on the grade of concrete to be formed, which then gives us the proportions of all the components to be used. According to the results derived from the calculations, the drum is designed first according to the required capacity. To support the drum with the expected or assumed load the yoke, base frame and hand wheel are designed.

2. METHODOLOGY / CALCULATIONS

A. Calculations –

a. Fix the concrete grade.
b. Assume mass of cement.
c. Determine mass of sand and gravels (aggregates) based on the standard proportions for the chosen grade.
d. Compute the mass of one batch.
e. Select the FOS for the design. (2 in our case)
f. Compute the mass to consider for design purpose depending on the FOS. (Assumed mass)
g. Calculate the volumetric capacity by referring to the standard value of density of the chosen grade.
h. Determine the drum dimensions based on the above calculations.
i. Calculate the mixing force. Selection of a standard motor (2HP & 25 RPM)
j. Concrete Grade : M10
k. Ratio of Components = 1:3:6

Data for Calculations:

a. Mass of Cement = 10 Kg
b. Mass of Sand = 30 Kg
c. Mass of Gravel = 60 Kg
d. Mass of Water = 5 Kg
e. Total Mass = 105 Kg
f. Factor of Safety = 2
g. Assumed Mass (Total Mass x FOS) = 210 Kg
h. Volumetric Capacity = 0.0808 m^3
i. Length of Drum = 0.5 m
j. Diameter of Drum = 0.45 m
k. Thickness of the Drum = 6mm
l. Mixing Force (Assumed Mass x g) = 2060N
m. Minimum RPM of Drum for proper mixing = 25
n. Power of Motor = 1.49 kW (2HP)
o. Torque of Motor = 900 Nm

So, the total Load acting on the yoke
(or the main frame) during the process of mixing =
DRUM ASSEMBLY LOAD + LOAD DUE TO
ONE FULL BATCH = 2989 N

Determination of Maximum force required:

$W = M_T \times g$

M_T = Mass of concrete + mass of drums
= (105+200)
= 305 Kg

Therefore Force required for proper mixing = (305 x 9.8)
= **2990N**

Determination of Mixing Volume:

$Vmc = \pi r^2 h$

Vmc = Volume of Mixing chamber
r = 0.225m
h = 0.500m

$\therefore Vmc = \pi \times (0.225)^2 \times (0.5)$
$= 0.80\ m^3$

Determination of Belt Length:

$L = \pi(r1 + r2) + 2x + (r1 + r2)^2 / x$

r1 & r2 = Radii of Smaller and Larger Pulleys

x = Distance between the centre of 2 pulleys
= 2d1 + d2
= 2(0.070) + 0.135
= 0.275 m

∴ L = 0.32185 + 0.55 + 0.003
L = 0.875 m

Determination of Lap Angle:

$\alpha = 180 \pm 2\sin^{-1} (D_2-D_1/2C)$

For open belt, (used in this case), α is given as:

$180 – 2\sin^{-1}(D_2-D_1/2C)$

∴ α = 180 – 13.575
= 166.425°

Number of teeth on Ring Gear of Drum:

Motor: 2HP, General Purpose, 3 Phase & 500 RPM

Considering that 25 RPM is adequate for proper mixing,

D_1 = Diameter of driver pulley = 0.070m

D_2 = Diameter of driven pulley = 0.135m

N_1 = Speed of Driver = 500 RPM

N_2 = Speed of Driven

∴ $N_1/N_2 = D_2/D_1$

∴ $N_2 = N_1 x D_1/D_2$
= 500 x 0.070/-0.135

∴ N_2 = 260 RPM

N_B = Speed of Bevel Gear = 260 RPM

N_B = 260 RPM

N_R = 25 RPM

T_B = 13 (Standard)

∴ $N_B \times T_B = N_R \times T_R$

260 x 13 = 25 x T_R

∴ T_R = 260 x 13/25
= 135

Determination of Torque:

T = Fl

T = Torque

F = Mixing Force = 2990 N

L = Length of Paddle = 0.30m

∴ T = 2990 x 0.30
= 900 Nm

Determination of Shaft Speed:

N = 500 RPM

D_S (Shaft Diameter) = 0.10 m

$V = \pi D_N / 60$
= 3.142 x 0.10 x 500 / 60
= 2.6m / sec

B. Mass distribution table –

SR NO	PART	MASS (kg)	EQUIVALENT WEIGHT (g = 9.8) (Kg m/s^2)
1	MAIN ASSEMBLY	261	2557.8
2	DRUM ASSEMBLY	200	1960
3	STORAGE SPACE INSIDE DRUM (ASSUMED MASS)	210	
4	YOKE	9.3	91.14
5	MAIN FRAME ASSMEBLY	47	460.6
6	OTHER SUPPORT COMPONENTS	5-6 (approx.)	53.9
7	ONE FULL BATCH	105	1029

Table 1-Mass Distribution Table

C. Motor Assembly Dimensions:

SR NO.	COMPONENT	LENGTH (m)	DIAMETER (m)	NO.OF TEETH (m)
1	Small Pulley	-	0.070	NA
2	Big Pulley	-	0.135	NA
3	Shaft 1	0.150	0.100	NA
4	Shaft 2	0.270	0.100	NA
5	Bevel Gear	-	0.102	13

Table 2-Motor Assembly Dimensions

D. Dimensions of Concrete mixer assembly:

SR NO.	PART	HEIGHT/ LENGTH (m)	DIAMETER (m)	WIDTH (m)	NO. OF TEETH
1	DRUM LOWER	0.5000	0.450	0.060	NA
2	DRUM TOP	0.5000	0.450	0.060	NA
3	DRUM BRACKET	0.1000	0.250	-	NA
4	YOKE	0.900	0.050	-	NA
5	MAIN FRAME	1.215	-	1.260	NA
6	WHEELS	-	0.300	0.040	NA
7	RING GEAR	-	0.920	0.040	135
8	HAND WHEEL	-	0.500	-	NA

Table 3-Dimensions for Concrete Mixer Assembly

3. DESIGN

3.1. Design of the Drum –

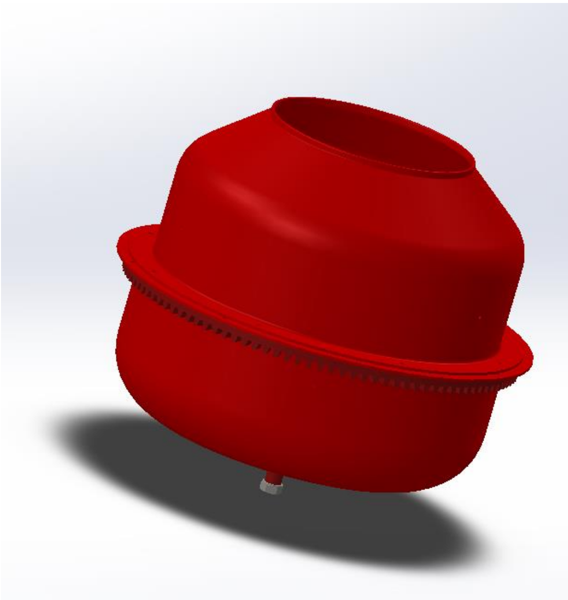

Figure 1-Design of Drum (1)

Figure 2-Design of Drum (2)

3.2. Main Frame Assembly –

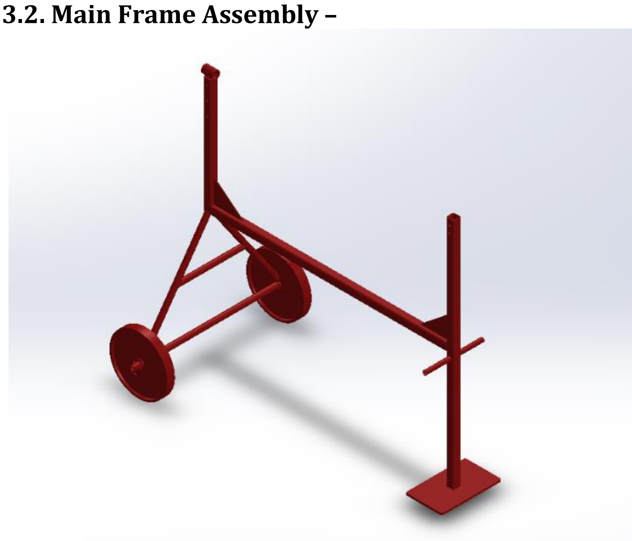

Figure 3-Main Frame Assembly (1)

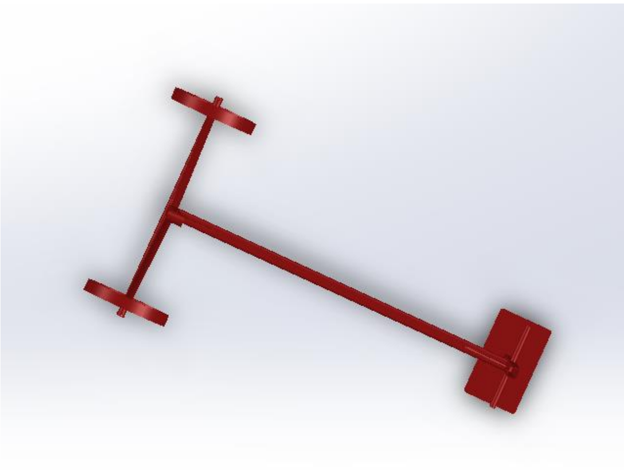

Figure 4-Main Frame Assembly (2)

3.3. Design of Yoke -

Figure 5-Design of Yoke

3.4. Motor assembly -

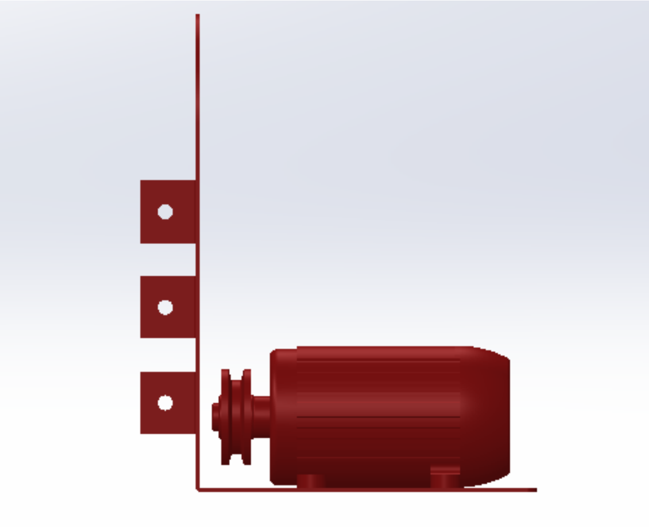

Figure 6-Motor Assembly (1)

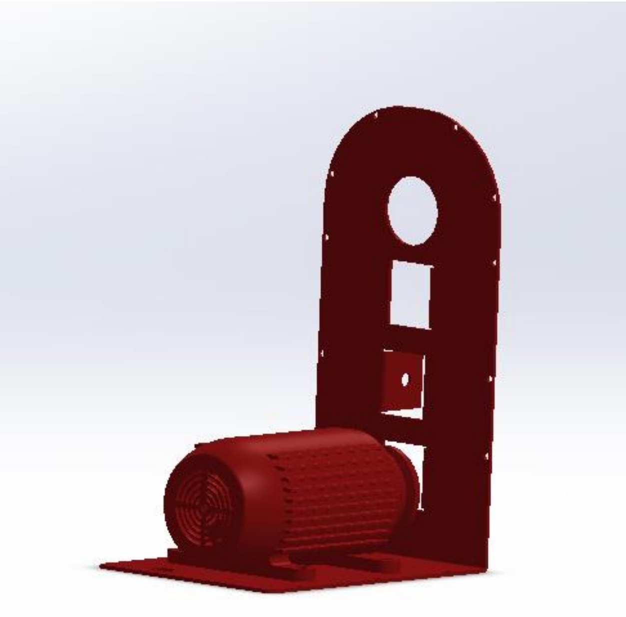

Figure 7-Motor Assembly (2)

3.5. Design of Motor Casing -

Figure 8-Design of Motor Casing (1)

Figure 9-Design of Motor Casing (2)

3.6. Design of Blade –

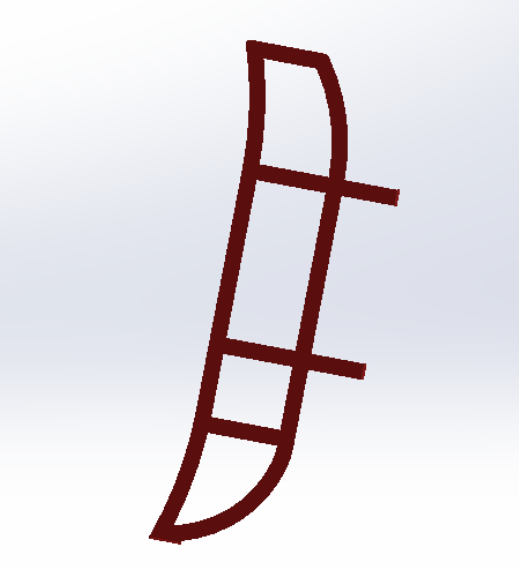

Figure 10-Design of Blade (1)

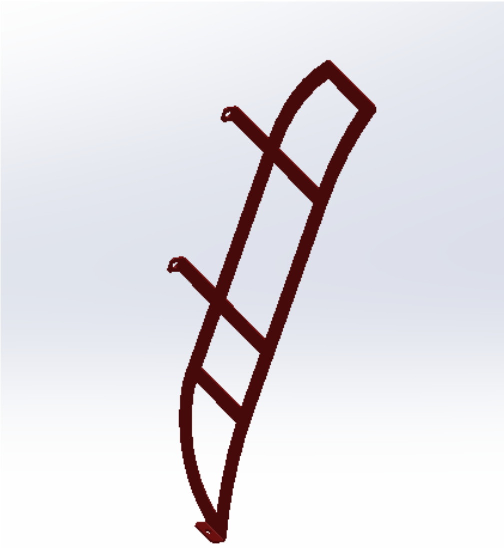

Figure 11-Design of Blade (2)

3.7. Complete Assembly of Portable Concrete Mixer –

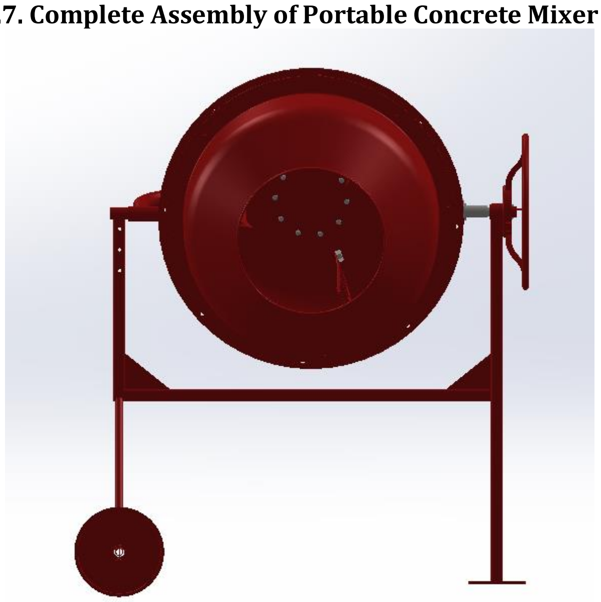

Figure 12-Assembly of Portable Concrete Mixer

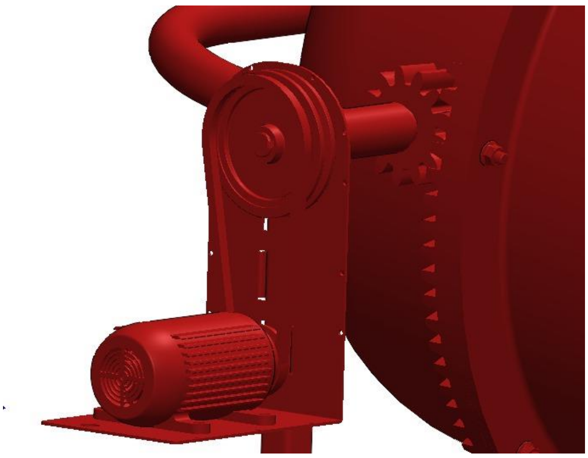

Figure 13-Assembly of Portable Concrete Mixer (2)

Figure 14-Assembly of Portable Concrete Mixer (3)

2. ANALYSIS

2.1 Analysis of Yoke -

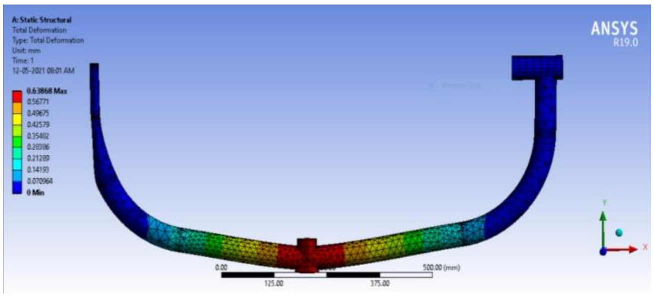

Figure 15 Yoke

Maximum Deformation Observed = 0.63mm

2.2 Analysis of Blade -

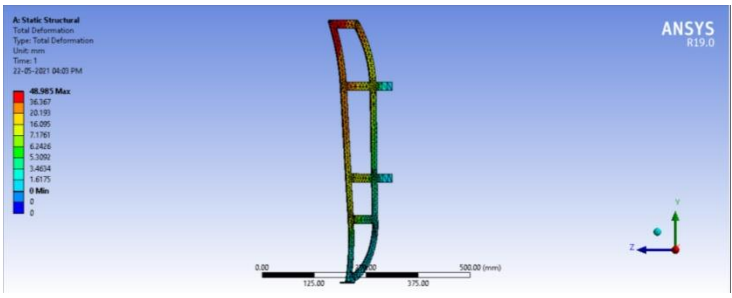

Figure 16 Blade

Average Deformation Observed = 4.8mm

2.3 Analysis of Main Frame –

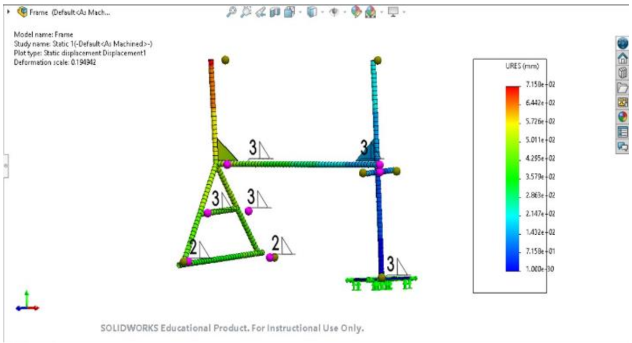

Figure 17 Main frame

Maximum Deformation Observed = 7mm

2.4 Analysis of Drum –

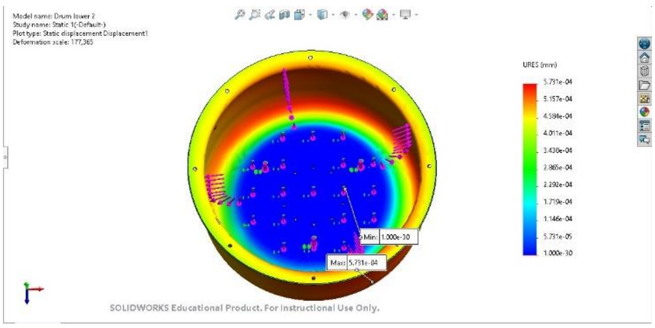

Figure 18 Drum

Maximum Deformation Observed = 5mm

3. CONCLUSIONS

Concrete has a continuously growing demand especially in developing countries. There is a constant requirement of concrete no matter how big or small the construction project is. To fulfil this demand in the fast-paced world we are living in, mechanization of the process is required. After considering all the calculations, a portable concrete mixer was designed to fulfil the requirement of forming the M10 grade concrete. The design is completely safe as the deformations in the parts observed were within the limits and because of which the assembly would not fail. Mixing is a complicated process because of which we have to take into consideration factors like duration, loading method and energy of mixing. As a result, stainless steel was selected as the material for blade with which the design overcomes factors such as strength or corrosion.

ACKNOWLEDGEMENT

The objective of this project is to provide clear understanding of the process with which a portable concrete mixer can be designed. To achieve this objective, the group members by no means have worked alone as these ideas have been shaped by comments, suggestions and acceptance given by Prof. Moreshwar Khodke, Department of mechanical Engineering. We are thankful to Prof. Moreshwar Khodke his guidance, support and inputs in this course project without which it would not have been a success. We are thankful to Prof. (Dr.) M.B. Chaudhari Head of Department of Mechanical Engineering for his support and for the addition of such kind projects in our curriculum. We express our sincere thanks to the management of Vishwakarma Institute of Technology, Pune for allowing us to carry out such educational projects. We express our feelings and respect towards our parents, without their blessings, help and motivation this project could not be completed and would have been just a dream for us. We are thankful to all those whom we might have inadvertently failed to mention here but have a positive contribution in successful completion of this project.

REFERENCES

[1] Pharmaceutical engineering and mixing by: - Dr. Bhawan Bhatt.

[2] Concrete Mixing Methods and Concrete Mixers: State of the Art Journal of Research of the National Institute of Standards and Technology. By Chiara F. Ferraris.

[3] Artin Levon edition 1983 at chapter 8 of Molds and Scaffolding.

[4] Ristow G H 2000 Mixing and segregation in rotating drums, Proc. Symposium on Segregation in Granular Flows, The Netherlands: Kluwer Academic publishers, 311–320.

[5] Turbula T2C Heavy-Duty Shaker-Mixer 2004 www.artisanscientific.com/ 49853.asp accessed 12.06. 2007.

[6] Ferraris, C.F., "Concrete Mixing Methods and Concrete Mixers: State of the Art", Journal of Research of the National Institute of Standards and Technology, Vol. 106, No. 2, 391-399 (2001).

[7] Thompson Aguheva, "Design and Fabrication of an Industrial Mixer", International Journal of Practices and Technologies, ISSN 1583-1078, Issue 20, January-June 2012.

[8] Siddhant Dange, Saket Sant, Anish Sali, Parthon Pethodam, Sandeep Belgamwar., "Study of planetary concrete mixer", International journal of latest research in engineering and technology, ISSN 2454-5031, Volume 2, Issue 4, April 2016.

[9] Amruta K. Wankhede, Dr. A.R. Sahu Design, "Modification and Analysis of Concrete Mixer Machine", International Journal on Recent and

[10] Innovation Trends in Computing and Communication, Volume:3 Issue: 12 6613 – 6616, ISSN: 2321-8169, 2015.