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# Design and Analysis of Power Screw for Manhole Cover Lifter

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***Abstract*: The importance of manhole in the sewerage system is to get the underground pipelines and alternative systems area unit in good shape. A manhole cover is a detachable plate setting the roof above the manhole opening, to prevent anything from dropping in, and to stay away from unauthorized persons and matter to fall in it. Manhole covers are usually manufactured of cast iron, concrete or combine both. This creates them economical, powerful, and dense, generally weighing more than 50 kg. The weight supports to maintain them in position when transportation moves across them and makes it complicated for an unauthorized person not having proper tools to remove them. The traditional method of removing the manhole with the assistance of the hook. So, to safely remove the manhole cover, many innovative and automated techniques are designed and used for analysis. In this paper, the finite element analysis of a power screw operated manhole cover is analyzed with the help of ANSYS R14.5.**

***Index Terms*: Sewerage System, Manhole Cover, Power screw.**

## I. INTRODUCTION

A manhole cover is a square, rectangular or cylindrical shaped thick plate formed of various materials such as cast iron or concrete and capped by a mounting ring over the opening of a manhole, to keep anybody or anything from falling in, and to keep out unauthorized persons. A manhole cover rests on a metal base, with littler inset edge which fits the cover. The base and cover are now and then called "castings", since they are typically manufactured by a casting procedure, commonly sand-casting methods. The covers generally highlight "pick openings," into which a snare handle instrument is embedded to lift them. Pick openings can be covered for an increasingly watertight top, or can enable light to radiate within. A manhole pick or hook is typically applied to lift them. However, different instruments can also be utilized, including electromagnets. All lifting devices involve an effort to be used at the input node over a massive displacement. This effort is transmitted to the output node whose movement is relatively small as compared to the input node. As the work is conserved, a more significant force is obtained at the output node.

**Fig.1.Manhole Cover**

## II. HISTORY & BACKGROUND

The dangers in manually handling of any manhole cover, whether by direct application of hands or through hand-held manhole cover lifting keys. Authorized workers often involved in difficulties during removal of manhole covers, including back pain and hands injury. This is because of substantial lifting force is required to elevate manhole covers from its position, and additionally, it depends on the weight of the vehicle that passed over them and the existence of particulates such as dirt, debris, dust and paving material of the road. There are also several environmental factors associated with the safety of manhole cover, which are the weather, surface condition, and confined space. Most covers will exceed the advisable lifting limit for one person, hence beyond the range for a two-person lift. The covers usually emphasize "pick holes," within which a hook handle tool is entered for lifting (shown in fig.2). The laborers doing this work have met some obstacles when they lift the manhole cover for maintenance.

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So there is a requirement to design and analysis of modern power screw manhole cover lifter in position to enhance working efficiency.

**Fig.2. Hook for lifting a manhole cover**

## III. OBJECTIVES

1. The fundamental objective of the work is to make the task easier for the labor as well as the firm or department working on manholes and sewers based work.
2. The device is designed that various types of firms can use it just by doing minor modifications in the design. The device works on the principle of actuating the frame through the power screws.
3. The device consists of the main body of which is made up of mild steel and is welded together using D.C. arc welding and consumable electrodes. Thus it must be light in weight and quickly transfer from one place to another.
4. The power screws attached at the end of the frame and to support the frame one end is provided with a base plate, and another end is equipped with wheels to balance the device.
5. The device saves time as the operation performed by device is smoother and faster as compared to labor doing the same process.

## IV. BENDING OF BEAMS

In Applied mechanics, bending (also recognized as flexure) describes the role of a slender structural component suppressed to an outside load acted perpendicularly to a longitudinal axis of the element. As per Euler–Bernoulli assumption of slender beams, a primary hypothesis is that 'plane sections remain plane.' In another statement, any deformation due to shear stress over the region is not considered for no shear deformation. Additionally, this extended arrangement is suitable if the highest stress is smaller than the yield stress of the element. For stresses which come more than yield, refer to report plastic bending. Through yield, the highest stress encountered in the region is defined as the flexural strength

Bending Formula (Euler-Bernoulli Bending equation)

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

Where,

M = Bending moment acting at the given section

σ = Bending stress

I = M.I. of the cross-section around the neutral axis

y = Distance from the neutral axis to the extreme fiber

E = Young's modulus of the material of the beam

R = Radius of curvature of the beam.

## V. DESIGN OF POWER SCREW MANHOLE COVER

For designing of power screw manhole cover the material for beam, screw and nut are SAE1040 (IS C40), SAE1117 hot drawn and as Cast Iron I.S. grade 20. The weight on each screw is taken as 2000 N. Lift of the cover is taken as 600 mm, and the length of the beam is 1.2 m. The points of suspension of load are at 0.4 m from each end.

### A. *Design of Screw*

Load on each screw, W = 2000 N

$$S_{yt} = \frac{F_{cr}}{A}\left[1+\frac{1}{\frac{C\pi^2 E}{S_{yt}}}\left(\frac{l}{k}\right)^2\right] = \frac{F_{cr}}{\frac{\pi}{4}d_c^{\,2}}\left[1+\frac{1}{\frac{C\pi^2 E}{S_{yt}}}\left(\frac{l}{k}\right)^2\right]$$

Also,

$k = \frac{d_c}{4}$, C=0.25 (one end fixed, other free)

$$309 = \frac{2000}{\frac{\pi}{4}d_c^{\,2}}\left[1+\frac{1}{\frac{0.25\times\pi^2\times 206000}{309}}\left(\frac{600\times4}{d_c}\right)^2\right]$$

Where $d_c$ is the core diameter. Solving for $d_c$ we get,

$d_c = 13.19\text{ mm} \approx 14\text{ mm}$

From T-VI-5 of Design Databook by B.D.Shiwalkar, Selecting

d = 22 mm, Pitch = 5 mm

$d_c = d - \text{pitch}$

$d_c = 22 - 5 = 17\text{ mm}$

Mean diameter of the screw, $d_m = \frac{22+17}{2} = 19.5\text{ mm}$

helix angle, $\alpha = \tan^{-1}\left(\frac{1}{\pi d_m}\right) = 4.66°$

Assuming the coefficient of friction, $\mu = 0.2$

friction angle, $\phi = \tan^{-1}(0.2) = 11.31°$

The torque required to raise the load,

$$T = \frac{W\,d_m}{2}\tan(\alpha+\phi) = \frac{2000\times 19.5}{2}\tan(4.66+11.31)$$

$T = 5580.48\text{ N.mm} = 5.58\text{ N.m} \approx 6\text{ N.m}$

Efficiency,

$$\eta = \frac{\tan\alpha}{\tan(\alpha+\phi)} = 0.2848 = 28.48\%$$

As $\eta < 50\%$ therefore the screw is self-locking and thus satisfies our requirement.

Force applied by one hand on each screw.

$F \times L_h = T = 6\text{ N.m}$

Assuming the length of the handle, $L_h = 20\text{ cm} = 0.2\text{ m}$

We get$= 30\text{ N}$, which is the force applied by one hand

### B. *Design on Nut*

Taking material as CI IS grade 20, Sut = 271 MPa

Taking F.S = 6, Sdt = 271/6 = 45 MPa

Specified bearing pressure, Pb

= 4 MPa

$$R_b = \frac{W}{A} \Rightarrow 4 = \frac{2000}{\frac{\pi}{4}(22^2 - 17^2) \times n}$$

Therefore, the number of turns, $n = 3.26 \approx 4$ turns

Height of nut = $n \times \text{pitch} = 4 \times 5 = 20$ mm

The outer diameter of the nut

$$S_{dt} = \frac{W}{A} \Rightarrow 45 = \frac{2000}{\frac{\pi}{4}(D^2 - 22^2)} \Rightarrow D = 24.43 \text{ mm} \approx 28 \text{ mm}$$

### *C. Design of Beam*

As shown in the Free Body Diagram, the beam will be supported on the screws at points A and B. The load will be applied at points C and D where the chain or wire rope will be attached using a pin and the manhole cover will be suspended on the chain or wire rope. The load is steadily applied downward transverse load; hence, the beam is assumed to be in a state of pure bending; thus, Euler-Bernoulli Bending equation is used for design.

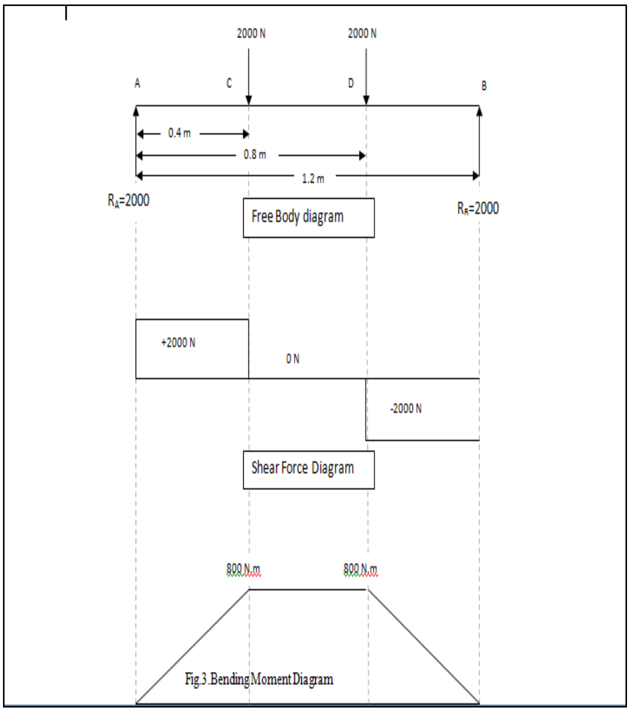


**Fig.3.Bending Moment Diagram**

The principle of equilibrium of forces finds reactions at supports

$R_A$ = 2000 N and $R_B$ = 2000 N

Bending Moments at the points C and D respectively are

$M_C$ = 800 N.m and $M_D$ = 800 N.m

Selection of cross-section

Selecting ISNT (Indian Standard Normal Tee) bar for the beam. Size of the ISNT bar is determined by trial and error which involves selecting the appropriate dimensions from PSG databook which satisfies the bending equation under given load conditions.

From PSG Databook, Page 5.132, Select ISNT 60 for which,

- h = 60 mm, b = 60 mm, $t_f$ = 6 mm, $t_w$ = 6 mm, Cxx = 15.6 mm , Ixx = 21.4×104 mm4

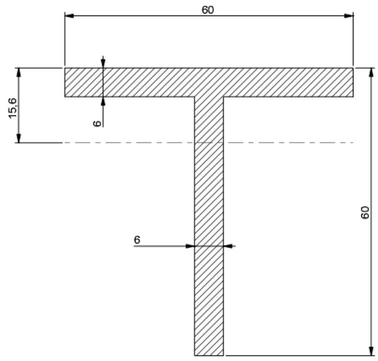


Fig.4.Cross-section of beam

Assuming Factor of safety (FOS) = 2, design stress for beam material is,

$$S_{dt} = \frac{S_{yt}}{fos} = \frac{350}{2} = 175 \text{ MPa}$$

Consider,

$$\frac{M}{I} = \frac{\sigma}{y} \Rightarrow \frac{800 \times 1000}{21.4 \times 10^4} = \frac{\sigma}{60 - 15.6}$$

Thus, induced stress,= $166 \text{ MPa} < S_{dt}$

Hence the design is safe.

B

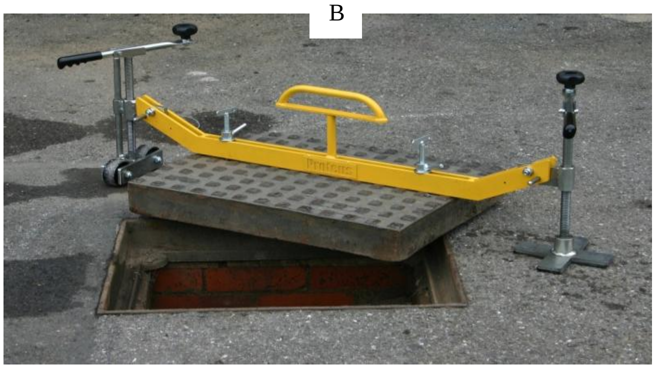

**Fig.5. Actual Model of Power Screw Manhole Cover Lifter**

## VI. A CAD MODEL OF POWER SCREW MANHOLE COVER

Based on the design criteria, the CAD model is prepared with the help of PRO/E wildfire 5.0. Based on the design calculation, the induced stress comes out to be 166Mpa which is less than the design stress of 175 MPa, and therefore it is safe to design with the help of a load of 2000N on each screw.

**Fig.6.Pro-E Model of Power Screw Manhole Cover**

## VII. RESULT OF ANALYSIS OF POWER SCREW MANHOLE COVER

1. Analysis of Beam: The static structural analysis of beam is done with the help of ANSYS 14.5, and the Max normal stress comes out to be 92.879 MPa. The equivalent Von Mises stress comes out to be 27.69 MPa across the beam, and max Von Mises stress comes out to be 245.36MPa. The material used for the beam is SAE1040 (IS C40), and its yield strength of the material is 350 MPa. So, the Von Mises Stress is less than the yield strength of the material. Therefore the beam can sustain the load applied on it.

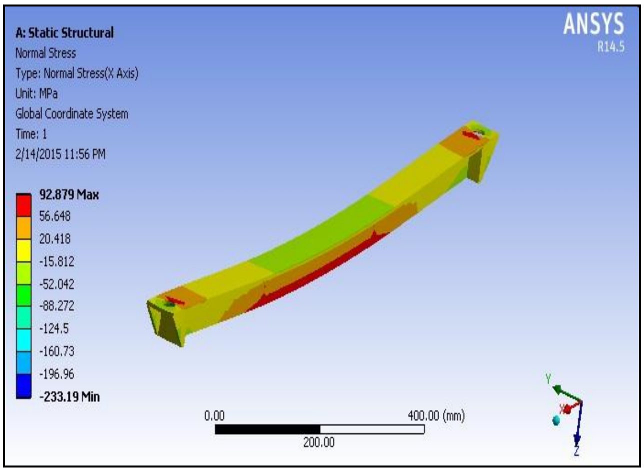


Fig.7.a Static Structural analysis of beam

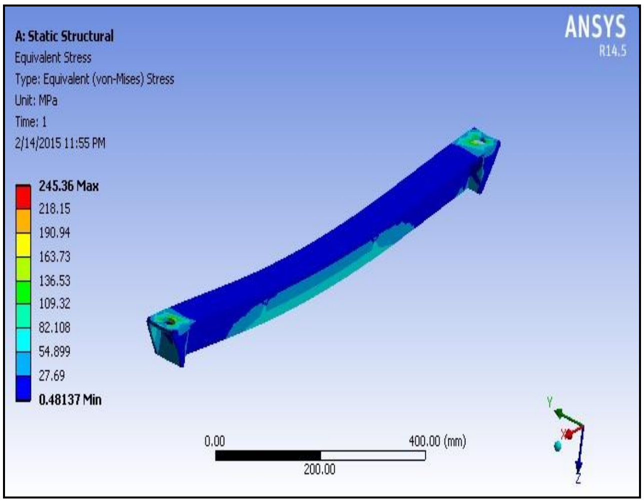


Fig.7.b Von Mises stresses in the beam.

2. Buckling analysis of screw : The critical area where the deformations are likely to occur is head of the screw where there is maximum stress which comes out to be 1.2462 MPa. The Maximum value of Von Mises stress happens at the head of the screw is 16.603 MPa. The material for the screw is SAE1117 hot drawn, and its yield strength is 309 MPa. So, the maximum Von Mises stress is less than the yield strength; therefore, it is proved that screw can lift the manhole cover plate.

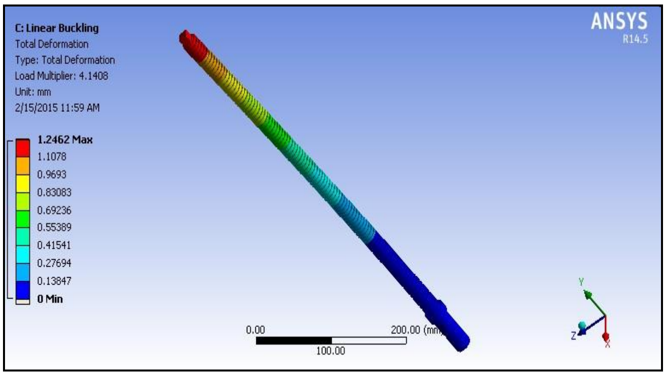


Fig.8.a Buckling analysis of screw

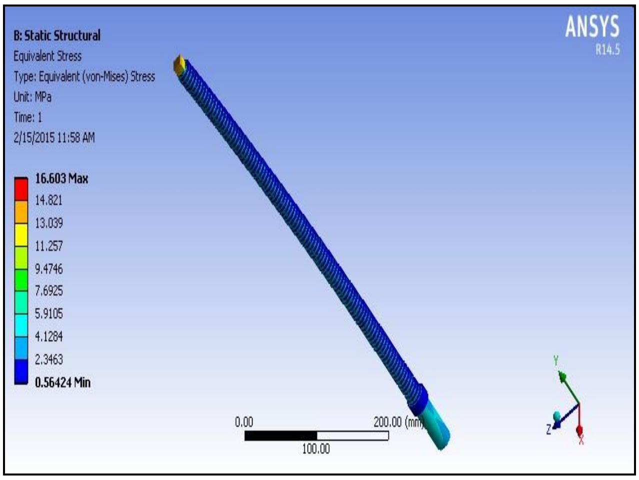


Fig.8.b Von Mises stresses of screw

## VIII. CONCLUSION

The project aims to develop a manhole cover lifter device which is designed to lift the heavy covers of manholes and sewers. The device is so designed that a person can easily lift the heavy cover with less effort. The device is so designed that any skilled or unskilled worker can operate it. The device saves the labor cost and time, and it reduced the dependency on labor.The aim behind the project is to ease the work for labor and engineers to perform work in manholes of cable ducts and manholes and to have a better option than to use a number of a laborer for the same work to be done.

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