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Design Analysis and Experimental Investigation of Adjustable Height Manhole System

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Abstract

This is often seen that when the roads are to be repaired or re-tarred the man holes get covered up due increase in height of the road and hence they have to reconstructed to adapt to the height of the road else Misaligned manhole frames in streets often cause driving hazards, failure of pavement around the frames, cause poor access to manholes, may be responsible for inflow and infiltration and can also result in other problems. Because manhole frames are not manufactured to be adjustable, an effort to make repairs is time consuming and often in effective. Thus there is a need to develop an height adjustable manhole system where in manhole system be constructed by casting the manhole by suitable method according to the Indian Standard so as to make the system flexible enough to adjust the height of the manhole as per requirement. The scaled model of the height adjustable manhole will be made and solid modeling using Unigraphix software will be done to determine optimal dimension of gear-shaped parts through bending stress formulas and application Ansys work bench software to validate the strength of the manhole analytically. Fabrication of the scaled model will be done after appropriate selection of the nodular cast iron frame work, for nut and screw parts where as the holder elements will be developed by fabrication. Testing will be done by suitable methods to determine and experimentally validate the strength of the developed part of the manhole.

Keywords: height adjustable manhole Unigraphix, solid modeling, Ansys , Fabrication

1. Introduction

There are many kinds of manholes on residential streets such as for water supply and drainage, sewage, telecommunication cable, traffic sign, electricity supply, etc. According to their applications, cast iron, polyethylene, or concrete is used as the material. Traditionally manhole is repaired by excavation, manhole replacement, backfilling and then restoration of the site to its original condition.

The existing manholes are not constructed to adjust their height, therefore they should be entirely excavated to reinstall. This entire excavation of a manhole is not cost-effective. The manholes are sunk due to the road repair, which becomes the safety issue for pedestrians and drivers on uneven roads especially at night.

Misaligned manhole frames in streets often cause driving hazards, failure of pavement around the frames, cause poor access to manholes, may be responsible for inflow and infiltration and can also result in other problems. Because manhole frames are not manufactured to be adjustable, effort to make repairs is time consuming and often ineffective.

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2. Literature review

Table 1: Some related studies

Sr. No.	Paper Name	Author Name	Summary
1	Development of a height adjustable manhole.	Ch. H. Kim, J.H. Park	Describes an optimal design of manhole, which deals with design elements of manhole which has gear-shaped stairs on the road to adjust its height.
2	Optimal design of a sewer line using Linear Programming.	Prabhata K. Swamee, Ashok K. Sharma	This paper is a step forward in developing optimal design approaches of sewer system.
3	Circular precast concrete manholes: experimental investigation.	Reem Sabouni and M.H. El Nagar	Evaluate the state of strains in the precast concrete manhole and state of stresses in the soil beneath the base to be used in developing enhanced guidelines for the design of their bases.

3. Problem definition

Misaligned manhole frames in streets often cause driving hazards, failure of pavement around the frames, cause poor access to manholes, may be responsible for inflow and infiltration and can also result in other problems. Because manhole frames are not manufactured to be adjustable, efforts to make repairs is time consuming and often ineffective. The cost of lifting the manholes to given road height amount to close to Rs 8000/- per manhole in India there by resulting in heavy cost of road building and repair.

Old, conventional methods would take close to an hour and in most cases structural integrity would be questionable with a very high failure rate, resulting in costly maintenance for years after. Setting frames properly is a heavy task. Manhole frames need to be set accurately with a road surface on longitudinal grade and with cross fall. And yet conventional manhole frame design and adjustment procedures that are typically used to make adjustments are not adequate to prevent failure. Manhole frames are heavy, cumbersome, and frustrating to adjust," he continued. Workers are required to lift the frame on and off the manhole opening several times while trying to find the right thickness of wood using rocks, wood shims, old pieces of broken asphalt or concrete, pieces of scrap metal from fabricating shops and all kinds of other materials. Even if grout is used, such materials can deteriorate or leave point loads on grade rings which ultimately damages and weakens the manhole chimney structure. Historically, adjusted frames in this manner are very unstable and get knocked off adjustment by road building and paving equipment. It's hard to believe, but without improvements, our industry has been setting frames like this for more than 100 years. In addition, current specifications for adjustments are insufficient and do not consider the importance and diversity of the task.

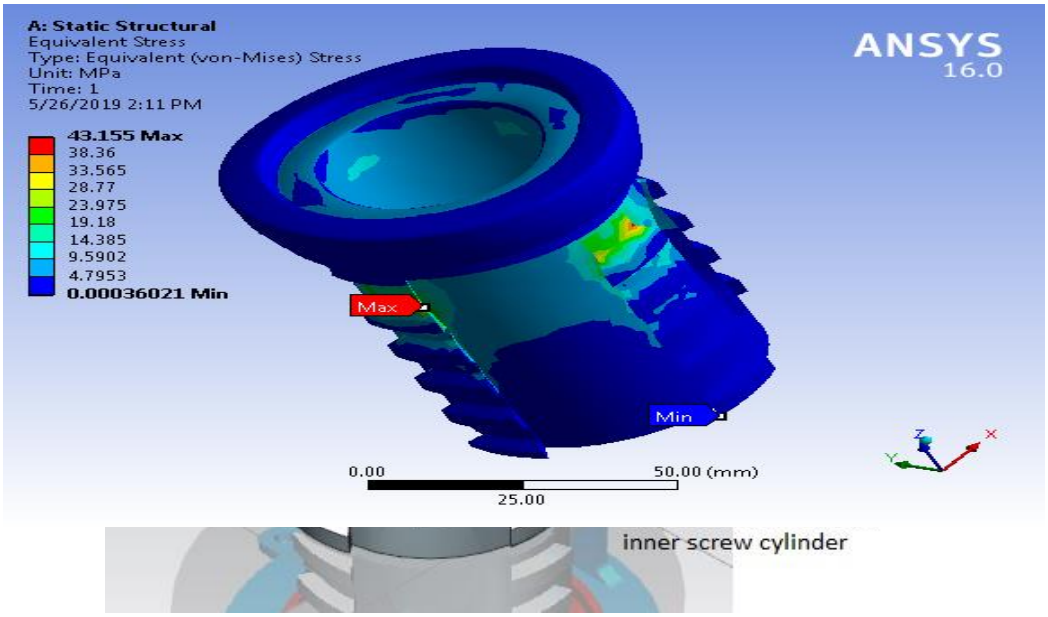

Figure 1: Height- Adjustable Manhole

Solution:

The purpose of this project is to introduce new-developed manhole and to determine optimal design. Refer Figure 1 This manhole is consists of cover, outer cylinder and inner cylinder which has gear-shaped stairs to adjust their heights. With the development of this height-adjustable manhole, the remediation and rehabilitation of underground manhole can be drastically improved. The replacement of new-developed manhole must be economical because it requires only 1-2 workers and simple adjustment of the height comparing with that the existing manholes is required 4-5 workers and reconstruction. The maintenance of this height-adjustable manhole only requires periodic check-ups. Inconvenience of reconstruction is totally eliminated. Use of this manhole must be drastically economical to install and rehabilitate manhole.

4. Method of analysis

4.1. Design and analysis of Manhole Cover Body

Selection of Material: according to EN 1563:2011
Mechanical properties of ductile iron grade EN-GJS-500-7 are following:
Modulus of Elasticity E = 169 GPa,
Poisson's Ratio = 0.275, Minimum Tensile Strength Rm = 500 MPa,
Minimum 0.2% proof stress Rp0.2 = 320 MPa,
Allowable Minimum Elongation A=7%
Design load = 9810 N
fc_{act} = 75.6 N/mm^2
As $fc_{act} < fc_{all}$; Body is safe in compression.

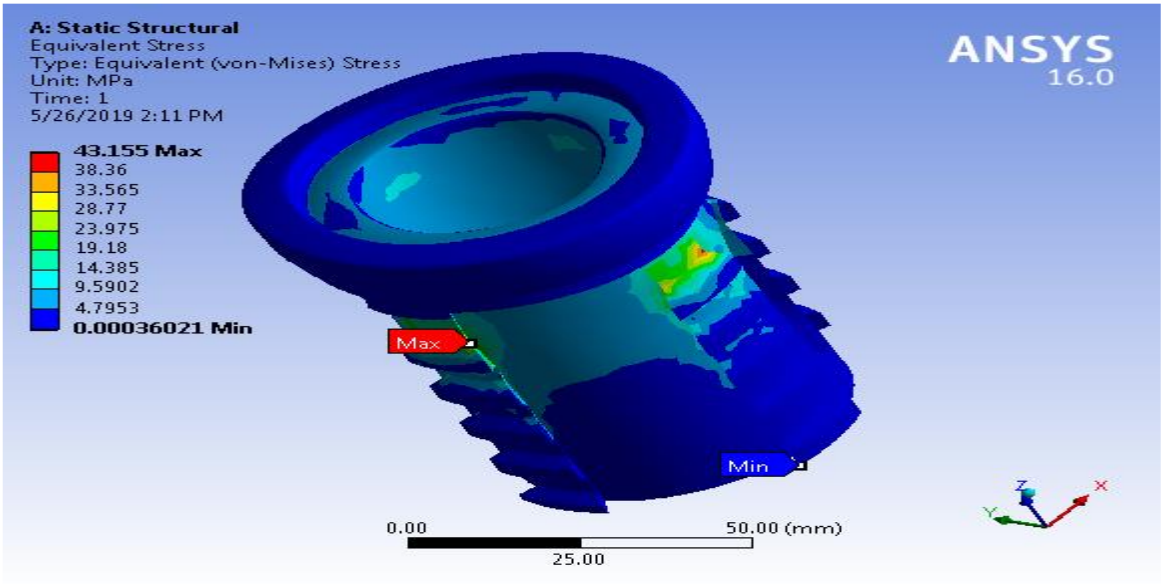

Figure 2: Maximum stress induced in the part material

In Figure 2, maximum stress induced in the part material is 43.155 MPa, which is far below the allowable stress of 320 Mpa. Hence, the body is safe.

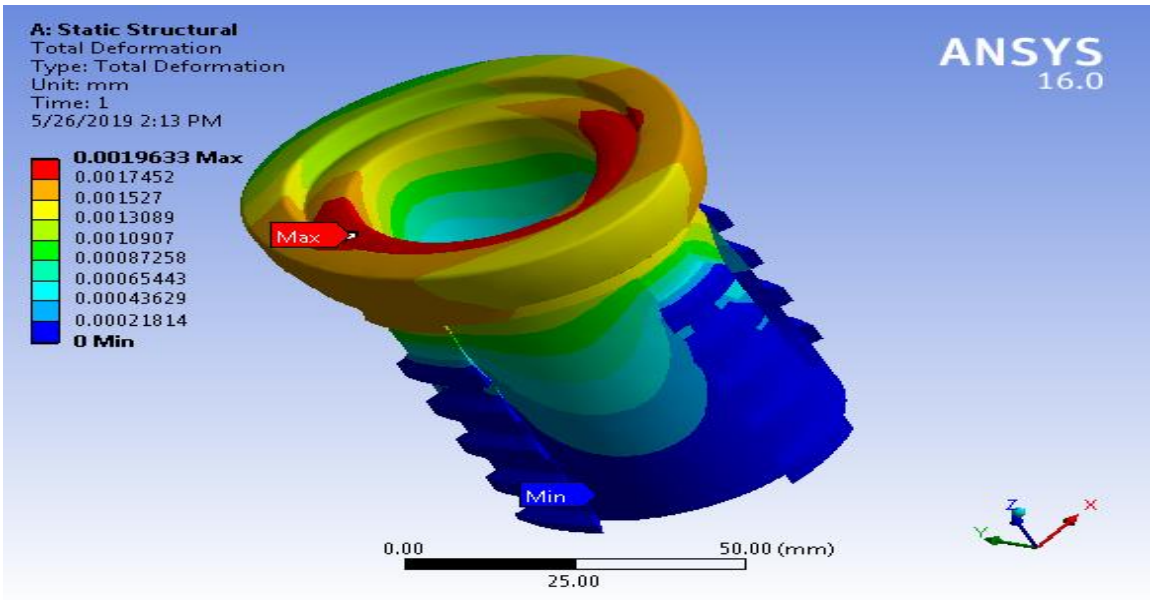

Figure 3: Deformation pattern

In Figure 3, maximum deformation is 0.0019 mm which is negligible hence the body is safe.

4.2. Design and analysis of Nut

Design load = 9810 N

fc_{act} = 45.6 N/mm^2

As $fc_{act} < fc_{all}$; Body is safe in compression.

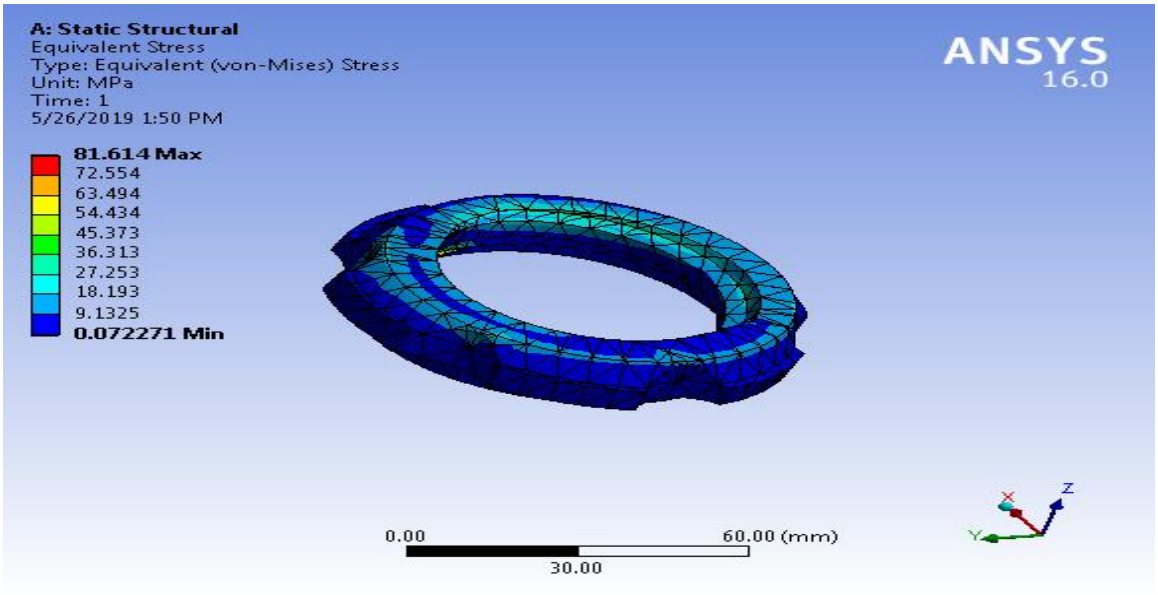

Figure 4: Maximum stress induced in the material of nut

In Figure 4, Maximum stress induced in the material is 81.61 Mpa, which is below the allowable stress of 320 Mpa. Hence, nut is safe.

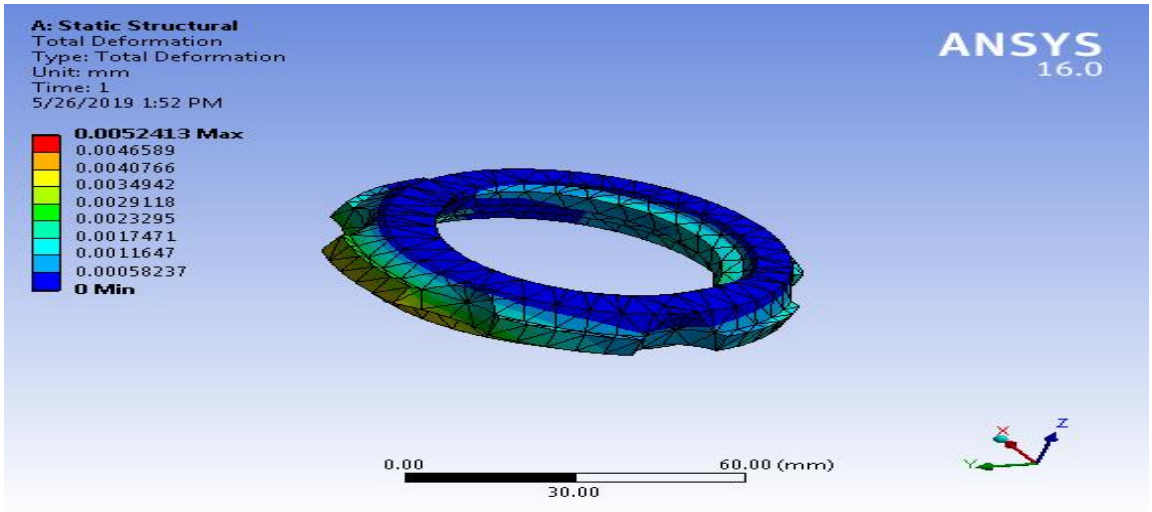

Figure 5: Nut deformation

In Figure 5, Nut shows a negligible deformation of 0.005 mm. Hence, the nut is safe.

4.3. Experimental procedure

Figure 6: Experimental Setup for Manhole

4.3.1. Objectives of testing

a. Determination of Maximum deformation at different loads
b. Maximum load carrying capacity:

Here in the maximum weight consideration was kept to 1 ton as that maximum load shared will be component of weight (W/4) of any vehicle as only one wheel will be possibly standing on the drainage at a time hence 9810 load is justified.

4.3.2. Procedure of trial

a. Place the component under the jaw system
b. Apply the load using hand lever to turn jack system
c. Note the deformation
d. Repeat Test

5. Results and discussion

Table 2: Result of deformation

Sr no.	Load (KG)	Analytical Deformation (mm)	Experimental Deformation (mm)
01	1000	0.019	0.021
02	1200	0.02536	0.026
03	1400	0.028	0.031
04	1600	0.032	0.035
05	1800	0.036	0.039
06	2000	0.039	0.042

Refer Table no.2 there is no significant difference in the values or trend of deformation and as the values are in close agreement it can be safely concluded that the experimental results are validated.

6. Conclusion

The design of the Body shows that the maximum stress induced calculated using theoretical method as well as the analytical method is well below the allowable stress in the material of the part hence it is safe, so also deformation is negligible. The design of the nut shows that the maximum stress induced calculated using theoretical method as well as the analytical method is well below the allowable stress in the material of the part hence it is safe, so also deformation is negligible. The analytical deformation is seen to increase with the increase in load. The experimental deformation is seen to increase with the increase in load. The comparison graph does not show any significant difference in the values or trend of deformation and as the values are in close agreement it can be safely concluded that the experimental results are validated.

References

[1] C.L. Hwang, J.W. Lee, M.S. Kim, *The Strength of Materials,* Bando Publishing Co., Seoul Korea, 2004

[2] Christian Falk, “Rehabilitation of Manhole Covers”, *Trenchless Technol. Res.*, 14, No. 2, 9-46. 1999

[3] G.R. Koerner and R.M. Koerner, "Geosynthetic use in trenchless pipe remediation and rehabilitation,*" Geotextiles and Geomembranes*, 14, 3-4, 223-237, 1996

[4] J.A. Westhoff and J.A. Kelly, “Improved water-tight manhole sealing”, *US patent No. 6126173 2000*

[5] C.G. Kang, P.K. Seo and Y.P. Jeon, *“Thixo die-casting process for fabrication of thin-type component with wrought aluminum alloys and its formability limitation”, Journal of Materials Processing Technology*, 160, 1, 59-69, 2005

[6] L. Cizek, M. Greger, L. Paulica, L.A. Dobrzanski, T. Tanski, “Study of selected properties of magnesium alloy AZ91 after heat treatment and forming*”, Journal of Materials Processing Technology*, 157-158, 466-471, 2004

[7] J. Gawronski, J. Szajnar and P. Wrobel, “Study on theoretical bases of receiving composite alloy layers on surface of acst steel casting*”, Journal of Materials Processing Technology*, 157-158, 466- 471, 2004