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High Mast Structures with Solar Powered Illumination System

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***Abstract*—Nowadays High Mast Structures (HMS) is being used widely in different regions of the world. These high mast structures are mounted with various types of utilities according to the functions they have to perform. The high mast structures are monotubular structures with slender design. The larger ratio of height to the horizontal dimension and mass of equipment at the tip makes the design of high mast structure slender and sensitive to the wind. When the high mast structures which are used for illumination purpose are mounted with solar panels at the tip for collecting solar energy, the cracks are observed after the interval of time. The cracks are occurred at the welded joint of tip of stiffener with the pole. This shows that the design of high mast structures which are used for mounting luminaries is not suitable for mounting of additional utilities of the solar panels. Therefore, the necessity arises to modify the existing design in order to sustain the extra load due to the solar panels and also it should meet the client's specification.**

Keywords*— *High Mast Structure, Stiffener

INTRODUCTION

High mast structures are the structures which are widely used in different regions of the world for various purposes. The used of high mast structures has a very wide range according to the utility equipment which is mounted at the tip of the structure. When equipped with lights, they are used for the illumination purpose, similarly when equipped with antennas they are used for transmitting signals, etc. the high mast structures are monotubular towers having greater diameter at the bottom than at the top with uniform taper. Because the diameter of these high mast is less than 1m, these towers are called high mast. The high ratio of horizontal dimensions to the height makes the structure slender. The increase weight of utility equipment at the tip add slenderness to the structures. As there is increment in the height of the structure, the slenderness increases. Therefore it is preferred to increase number of poles than in increasing its height. When the structures which are available for mounting halogen lights for illumination purpose, are mounted with extra utilities i.e. solar panels, then it is observed that the slenderness of the structures increases. Also after interval of times the cracks are being to form at the bottom of the structure. The crack are occurred at the welded joint of tip of stiffener with the pole. This creates the necessity to modify or to redesign the structures which will be capable of holding the whole structure along with all the mountings and for the long interval of time. Thus the main focus is given for the modification in the design of the stiffener. Then analysis is to be performed and safeness of the design is to be check under various criterion. Then the task is to be optimize the design of the stiffener so that it can withstand with given load and the aesthetic view of the structures should not get hammered.

I. LITERATURE REVIEW

A. Jing-Jong Jang, and Yi-Chao Li[1]

The force exerted by the wind causes the great effect on the performance of high mast towers. The diameter of these towers is less than 1metre. Therefore they are also called as monotubular mast structures. These high mast structures have the characteristics of light weight and cost efficiency. Due to this the stadium, airports, public places can be lighted efficiently. Otherwise by the use of conventional methods, illumination cannot be done effectively or the illumination poles get crowded. The reason of high mast structures to be very slender and sensitive to the wind is that it has a combination of the structural slenderness and the concentrated mass at the tip, thus becoming unstable. In this study it is assumed that the structure will undergo aerodynamic actions. These aerodynamic actions are divided partly along the axis of the shaft and partly concentrated in the geometrical centre of the masses. Due to this reason torsional load should be taken into consideration. Vortex shedding and galloping are the two factors which causes the across wind response. The along wind load has less effect as compared to the across wind load. Therefore consideration of across wind load is more important in the design of the high mast structure.

B. Syed Ibrahim Dilawer, Md. Abdul Raheem Junaidi, Dr.S.Nawazish Mehdi, G.M.Sayeed Ahmed[2]

In this study manufacturing of high mast pole with various specification is done. These are placed in different environmental condition. Then the economy and commissioning was being carried out on all specimens. The result shows that the specimen with taper, circular and hollow sections give the optimum results. The material considered here is mild steel. This is due to its properties. The high mast lighting poles are widely used in the intersection of highways, etc. Designing factors primarily include wind speed, diameter of high mast, height of high mast, material consideration. The across wind load is significantly more important than along wind load. The factors which give rise to across wind load is mainly vortex shedding and galloping. It is considered that diameter of a mast should be 2/3 times of the height of the mast. The buckling failure can be controlled by limiting the ratio of lateral deflection and height.

C. Ching-Wen Chien and Jing-Jong Jang[3]

This study is about the consideration of the wind loads. It is proposed that the body weight of high mast structures does not cause any severe effect on the design. However as the height to width ratio increases, the intensity of wind excitation increases with decreasing of structure damping. Properties of the high mast structures is quite different from the tower structure. When the mean designed wind speed is greater than the critical wind speed, then the resonance occurs which is very dangerous to the high mast. The design wind speed should be followed the local code of the area. It is recommended that high mast structures is to be designed with natural period less than one second, The recommended values for gust effect factor G, signals and luminaries.

D. Christopher M. Foley, P.E. Scott J. Ginal John L. Peronto Raymond A. Fournelle[4]

Whenever the structural components are used for various purposes under natural or environmental conditions then the corrosion takes place after a specific interval of time. Therefore in order to prevent these structures from corrosion, galvanising process is done. In this galvanising process, a thin layer of Zn is coated on the metal surface. This process may cause that some of the residual thermal stresses to be induced in the structures. A significant thermal gradient is to be induced throughout the structure by doing the galvanizing on both the sides, which is typically maintained at 894 degrees Fahrenheit. This process is known as double dipping. Although the effect of a double-dipping of a truss – type component of a full span sign support structure to be quantified subjecting fully - welded structures to significant structure to be quantified subjecting fully - welded structures to significant thermal gradient along portions of its potentially detrimental to the structure.

E. Paul Colegrove, Chukwugozie Ikeagu, Adam Thistlethwaite, Stewart Williams, Tamas Nagy, Wojciech Suder, Axel Steuwer and Thilo Pirling[5]

Welding is the process used to join two parts with each other. Joining takes place by melting the metal at the joining edges. Whenever the welding is done there occurred two main problems. These are residual stresses and distortion. During welding the metal melts. Due to this the molten zone is created. Around this molten zone compressive yielding place. This gives rise to the residual stresses. After welding process when the molten zone cools down, the area get contracts which causes a tensile residual stresses. This stress particularly acts in the longitudinal direction. After welding process, the residual tensile stress covers the area across the centerline of the weld. This gives rise to the balancing compressive stress further from the weld zone. The fatigue strength and toughness get reduced due to presence of tensile residual stress particularly when combined with any notches are defects associated with the weld bead.

F. E. Armentani, R. Esposito, R. Sepe[6]

The process of welding causes a rapid thermal expansion followed by a thermal contraction in the weld as well as in surrounding areas. This creates inhomogeneous plastic deformation and residual stresses in the welding process. Such type of joints can be analyzed under 2D nonlinear thermal and thermo mechanical analysis in order to evaluate residual stresses in the welding process. As the adverse effects of welding are thermal stresses, therefore the main consideration in the welding process is the thermal conductivity of the given material. Transient temperature distribution in the welded joint is highly affected by thermal conductivity large tensile longitudinal residual stresses are present near the welding bead and low transverse residual stresses are produced near the weldment but they are affected by thermal conductivity change.

G. Mark S. Molzen, Doug Hornbach[7]

Welding is the process accompanied by the grinding process in order to give the surface finish. When the weld is finished conventionally with the help of grinder the temperature rises due to friction caused by grinding. This increase in temperature creates the residual stress and surface brittleness. In this study it is observed at the residual tensile stresses due to the grinding process can approach the ultimate tensile strength of the material itself. The fatigue resistance of the ground part is also get affected due to the residual tensile stresses. The major cause of residual stresses is heat which is generated during grinding operation. Therefore the attention should be given to minimize the heat generation. The solution is to use proper coolant during grinding operation. This coolant helps in carrying away the heat generated during the grinding operation. The provision of coolant is readily available in the automatic grinders, but the problem is with the manual or hand grinders. When a gentle grind is applied with the help of automatic grinder, this would in effect cold work material and helps in inducing a slight amount of beneficial compressive stress at the surface. Another way to increase the fatigue properties of metal components is shot peening which is a cold working process. When the structures are to be performed in fatigue environment the stresses due to applied loads and residual stresses of manufacturing are to be considered during designing. The effect of these stresses can be minimized through heat treating and shot peening processes. Thus in this way, the fatigue properties can be improved.

II. CONCEPT OF SOLAR POWERED ARRANGEMENT

Conservation of non-renewable energy sources is the need of the overall world today. This can be achieved by making use of renewable energy sources. There is a great need to find any of the optional ways to the use of energy.

In this study one of the option is given attention of using solar energy for the illumination purpose. This illumination can be done with the help of high mast structures by mounting at the squares, intersection of the roads, public places like garden ground, etc. The concept is to fix the solar panels at the tip of the towers along with the lights. This arrangement gather the solar energy during day time and use it at night for the illumination purpose. In doing so, the panels which are mounted at the tip creates the extra resistance to the flowing wind. The effect of this can be observed at the bottom of the mast where cracks began to appear. The cracks are observed at the tip of the stiffener where the base plate of the mast is attached to the high mast.

Thus necessity arises to improve the design of the stiffener which can very well sustain the load of utilities as well as the solar panels. The welding which is done at the joint of the stiffener with high mast should also induced thermal residual stresses in the structure. So this factor should be also taken into consideration.

While calculating the load occurred at the tip of the structure, wind velocity is first to be determined. This wind velocity can be obtained from the local code of the city of region.

The formula for converting the wind velocity into the design wind velocity is given as-

$V_Z = k_1 \text{ x } k_2 \text{ x } k_3 \text{ x } V$

Where k_1 = Risk Coefficient

k_2 = Terrain Factor

k_3 = Topography Factor

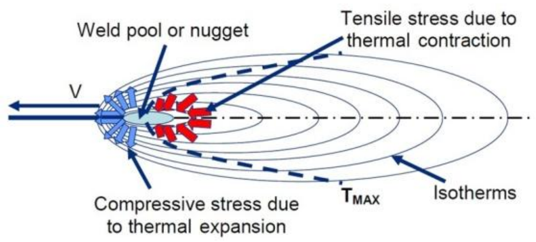
The wind impact on the longitudinal surface of the high masts thus is uniformly distributed in the form of pressure. This wind pressure from given wind velocity can be calculated by the formula-

Wind Pressure = $\frac{1}{2} \text{ x } \rho \text{ x } V_Z^2$ x Shape Factor

Where ρ = Density of the air

Thus by keeping the bottom of the high mast rigidly fixed, the force exerted by the wind pressure is applied at the top. The value for wind velocity is taken from local code and shape factor for the cylinder is taken and design of high mast is statically analyze. There is no need of considering the weight of the structure in static analysis as it has no effect while doing static analysis.

The welding operation is performed at the joint of stiffener with high mast causes to trap some of the residual stresses. In order to minimize it alternate welding should be performed on the either side of the stiffener. This avoids the matching of residual stresses on both the sides.



III. CONCLUSION

This paper has considered some of key factors associated with the design of HMS due to the effects of wind loading. The major findings are summarized as follows.

The design wind velocity is determined in accordance with local code and to meet the client's requirements for along-wind load of HMS. The wind loads are key considerations in the HMS design; bodyweight does not severely affect the design in this investigation. According to the results of this research, the projected area is more critical in this aspect. As for the intensity of wind excitation increases with increasing of aspect ratio (height-to-width). However, it decreases with increasing of structure damping. Consequently, the results of this research indicate that HMS is quite different from the tower structure. Furthermore, the body of the tip plays a major role in design

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