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Study of Castellated Beam Stiffened by Diagonal Andring Stiffners

Awadhut Chandrakant Dhage.[1] Prof. K. B. Pimpale.[2] Prof. A. S. Danole.[3]
[1]PG Student (CM), Department of Civil Engineering, JSPM's Rajarshi Sahu College of Engineering,
Pune, Maharashtra, India

Abstract: **Castellated beam are used as operational affiliates in multistory buildings, commercial, industrial and additionally in portal frames. The castellation procedure rises the overall depth of the parent section, this rise contribute effectually in adapting the strength of castellated beams in contrast with the asset of parental section. Castellated beams are steel beams with web beginnings and they enhancement its advantage due to its improved depth of section lacking any extra weight. However one significance is the presence of web opening. The presence of the web openings influences the member's failure behaviour around the openings, new local failure modes come into presence, such as the buckling of the web post between the openings, or yielding around the openings. Castellated beams with octagonal introductions frequently fail due to mesh post-buckling because of the enlarged depth. The current study is attentive on enlightening the performance of the castellated beam with octagonal openings using steel Ring stiffener and Slanting stiffeners. In this work, the modelling and analysis of the beam is done by using ANSYS software. Here two dissimilar models of castellated beam one with Diagonal stiffener and other with Ring stiffener were analysed. Both the beams were subjected to identical point load acting at the centre of the beam. The stress distribution and the deflections of the beams were moderately studied. It showed that the allowable load of castellated beams with Diagonal and Ring stiffener increased upto 138% and 163% respectively associated with parent beam without any openings. Thus the Ring stiffener is more effective as it carries 18% more load than Diagonal stiffener.**

Keywords — Castellated beam, web openings, stiffeners, web post buckling, diagonal stiffener, ring stiffener

I INTRODUCTION

Steel structure construction are attractive more and more general due to their various compensations such as the better satisfaction with the supple architectural, durability, strength to weight ratio, design, low inclusive cost.

Daily procedure of materials, design performs and construction methodology were trying to improve by presenting new aspect to give away improved outcome with situation to existing and past practice. The castellated beam is manufactured from its parent solid I beam by cutting it in crisscross pattern and both the splits are shifted and welded again, so that the depth of the beam rises.

Hence, due to upsurge in depth of beam load carrying capacity of the parent I section is enlarged with same quantity of material.

The intensification in sectional height results in the improvement of moment of inertia, sectional modulus, stiffness and flexural resistance of the sections.Sometimes, spacer plate can be added to obtain octagonal opening and this raises the depth up to two times of parental section depth.

The usage of stiffeners in the web portion of beam helps in curtailing the disappointments. Stiffeners are those structural components which are used to reinforce shear and moment resistance of the steel plates. Stiffeners are typically provided along the length or normal to the length. They are generally placed along the longitudinal side, coupled and along the edge of openings by additional appropriate and fusing work. Diagonal stiffeners should be provided on both the side of the beam so that it would be proportional about centreline of the web.The stiffeners along the edge of introductions are required to reduce the stress attentiveness near the openings.

Diagonal stiffeners are provided in order to tolerate the shear applied which more than that of the web of the beam.

The Ring stiffeners are useful in resisting the horizontal shear forces along the welding joints in the web-post especially with a slight indistinct distance between openings.

II. LITERATURE REVIEW

[1] B. Anupriya and Dr. K. Jagadeesan (2013), "Strength Study on Castellated Beam"

The writers studied systematically shear strength and deflection belongings of castellated beams with hexagonal introductions using ANSYS14. Study demos that, as the depth of castellated beam rises, the stress concentration at corners as well as at the loading point intensifications. In order to avoid this, study was also carried out by establishment of slanting stiffeners and also with slanting and vertical stiffeners (i.e. combined form) in the openings. The outcomes specify that minimum glances occur in the castellated beam provided with slanting and vertical stiffeners (joint form).

[2] P.D.Pachpor, Dr.N.D.Mittal, et.al, (2011), "Finite Element Analysis And Comparison Of Castellated & Cellular Beam" The disaster pattern and stresses developed under same loading condition are studied. In this work the no of beginnings is varied as 2, 4 and 6 in selected beam with hexagonal and circular shape of same cross sectional area. The support conditions are considered as fixed, hinged &roller. General 18 cases are studied for same chief point load & span with change of spacing of openings. As the no. of opening increases, the

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deflection also rises for the same support conditions. The extreme deflection is observed under roller support then fixed or hinged condition due to displacements at the ends. The determined von mises stress is also less in circular opening as compared to hexagonal opening of similar area.

[3] M.R. Soltani , A. Bouchaïr, M. Mimoune (2011), "Nonlinear FE Analysis of the Ultimate Behavior of Steel Castellated Beams"

M. R. Soltani et. Al. investigated behavior of punctured beam in order to study the web post buckling. The analytical study was carried out considering the features such as depth of opening, dimension of web and yield stress of the material by varying each of these factors and by keeping others constant. Comparable study was also carried out on castellated beam which was provided with intermediate plates (stiffeners). The boundary condition for all beams which were established was supported simply while the load was applied at top of the flange. The outcomes showed that thin webbed castellated beam exhibits web post buckling with limited plastic zone.

[4] Gopika S Nair , P.R. Sreemahadevan Pillai (2018), "Castellated Beam with Diagonal Stiffeners Along Hexagonal Cuts"

I beam with diagonal stiffeners along hexagonal castellation is considered in this study. . The load vs deflection beliefs found for stiffeners throughout castellation are is less compared to stiffeners provided along shear zone alone.The load vs equivalent stress and load vs maxi. principal stress values obtained for stiffeners along shear zone and stiffeners throughout castellation are almost similar, this implies that providing diagonal stiffeners along flexure zone don't have a distinguished influence on flexural strength possessions of the beam.

[5] Hayder W. Al-Thabhawee and Abbas A. Mohammed (2019),"Reinforcing the Octagonal Web Openings of Castellated Beam by Steel Rings"

The current study attentive on improving the behaviour of the castellated beam with octagonal introductions using steel ring stiffener and regulating the best dimension and distribution for the stiffeners.The outcomes showed that the ultimate and allowable load of reinforced octagonal castellated beams enlarged by (186%) and (160%) respectively by using additional steel material only (36%) from the weight of parent I-section, which the additional steel material consisted from the spacer plates and steel rings. Also, the consequences indicate that the best dimensions for the ring were when thickness equal to the web thickness of the parent section and the width equal to the half of the parent section flange width.

[6] Wakchaure M. R., Sagade A.V. and Auti V.A. (2012), "Parametric Study of Castellated Beam Varying Depth of Web Opening"

Wakchaure M.R. et. al, carried out tentative investigation on simply supported hexagonal castellated beam under two point loading. Methods of disappointment of the castellated were examined for dissimilar depths of openings. From the investigation, scientists accomplish that the castellated beam behaves acceptably up to a maximum depth of 0.6 times the depth of opening (0.6D). Detectives endorse for providing reinforcement (stiffeners) in order to avoid Vierendeel effects caused due to introductions.

[7] Sung C. Lee, M. ASCE, Chai H. Yoo and Dong Y. Yoon (2002), "Behavior of Intermediate Transverse Stiffeners Attached on Web Panels"

Sung C. Lee, et. al, analyzed three representations of plate girder without stiffener using software program. And the similar model providing with three plates stiffener are evaluated. The post buckling behavior of shear web panel was explicated using model called as shear equivalence It was found that the transverse stiffeners are not subjected to compression force. But the strength of the middle transverse stiffener is very important limit as it provides strength to the web of the beam.

[8] Jamadar A. M. and Kumbhar P.D.(2015), "Parametric Study of Castellated Beam with Circular and Diamond Shaped Openings"

Jamadar A. M. and Kumbhar P. D. carried out empirically as well as logically using Abaqus (CAE 6.13) of castellated beams provided with circular and diamond shaped openings by following the guidelines given in EUROCODE 3. The software results were validated by comparing it with investigational results. The result indicates that the castellated beam with diamond shaped opening suffers smallest amount of local failure as more shear transfer area is available as compared to the castellated beams with circular opening. Also load carrying capacity is larger for diamond shape than circular introductory.

[9] Konstantinos Daniel Tsavdaridis and Grigorios Galiatsatos (2015), "Assesment of Cellular Beams with Transverse Stiffeners and Closely Spaced Web Openings"

Konstantinos Daniel Tsavdaridis and Grigorios Galiatsatos (2015) studied computational reproductions of cellular beams using Finite Element Program. The behavior of cellular beams was done on the base of opening of cellular beam. The behavior of these web introductions was studied by other two limits namely thickness of web and thickness of stiffener of 20mm which were placed at the top and bottom, between flange and web connection. It was suggested that the stiffeners are viable only for s/d ratio between 1.2 and 1.3. It was also optional to provide ring stiffener (along edge of opening) [Fig-10] for opening with s/d > 1.3. Also behavior of transverse stiffener full or partial depth was recommended for further studies.

[10] Hideo Takabatake, Shigeru Kusumoto and Tomitaka Inoue (1991), "Lateral Buckling Behavior of I Beams Stiffened With Stiffeners"

Hideo Takabatake, et.al, experimentally investigated the adjacent buckling behavior of I beam with and without using stiffeners in the web portion of the beam. The beams provided with stiffeners and batten plates were placed at dissimilar positions along the length of the

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beam. The beam was restrained against twisting and lateral translation. From the experimental study it was observedthat lateral buckling of I beam was delayed due to web stiffeners and battens.

[11] Resmi Mohan & Preetha Prabhakaran(2016), "Finite Element Analysis to Compare the Deflection of Steel Beam with and without Web Openings"

Resmi Mohan & Preetha Prabhakaran (2016), In this paper, finite element analysis was completed to comparation the deflection of steel beam with and without web openings of ISMB 150 section. ANSYS 14.5 was used for the analysis. Outcomes showed that as compared to solid beam, steel beam with openings, showed more load carrying capacity and lesser deflection. The intensification in the depth of the section resulted to increase its strength. Moreover the Openings provided in web portion can help for the grant of passage of services through the beam without any abatement in strength also the provisions are provided through the web portions, so it will help to reduce the effective floor depth.

[12] Ajim S. Shaikh and Harshal R. Aher (2015), "Structural Aanalysis of Castellated Beam"

Ajim S. Shaikh and Harshal R. Aher, studied elementary behavior of the cellular beam using finite element method for two point loading where the limits were simply supported. During examination it was observed that on top of introductions and below openings stress concentration was developed in more amounts. So, it was advised to add extra plates to overawed the stability problem during erection.reasons for the delay in the study. Statistical analysis is performed to check whether the results of the survey lead to delays.

III. METHODOLOGY AND PROBLEM STATEMENT

In this work four models for castellated beam are developed using the ANSYS Software.All the castellated beams are having Six Octagonal web openings and are identical in dimensions. The first model is of the parent beam and the second is of the castellated beam without any stiffener. Also for the remaining models, one beam is provided Diagonal stiffeners and the other has Ring stiffeners.

The Load carrying capacity has to be determined by Finite Element analysis using ANSYS Software.The beams are simply supported and loaded by one concentrated load at mid-span with the material properties:-

Fy=324 MPa, Fu=452 MPa, Es=2.01x10^3 MPa

The parent castellated beam I-section was taken as IPE 140 of size 1700mm x 140mm x 74mm

flange thickness (tf)=7mm

web thickness (tw)=5mm

flange width (bf)=74mm

span length (L)=1700mm

overall depth of parent beam (d)=140mm

overall depth of castellated beam(D)=278.3mm

opening diameter (Do)=195.6mm

spacing between two openings centre to centre (S)=276.6mm

the clear distance between two successive openings (e) =81mm

IV. RESULT AND DISCUSSIONS

The load carring capacities are obtained for the different beams such as:-

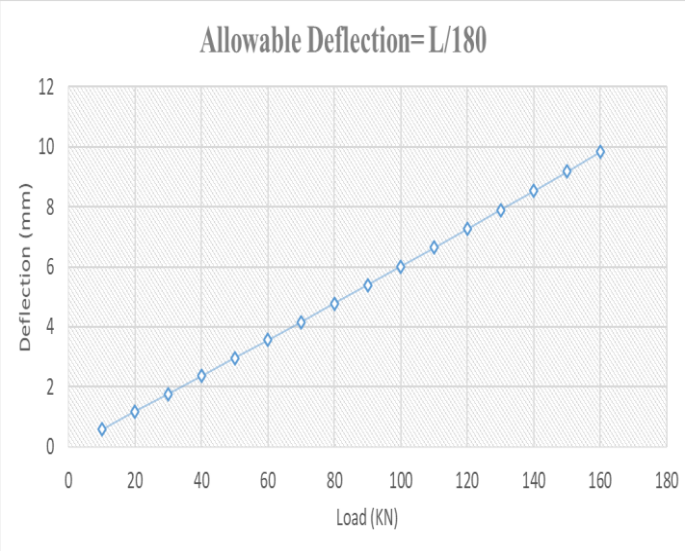
1)The parent beam which is the original beam from which the castellated beam is made.

2)The castellated beam of Octagonal openings but without any stiffeners.

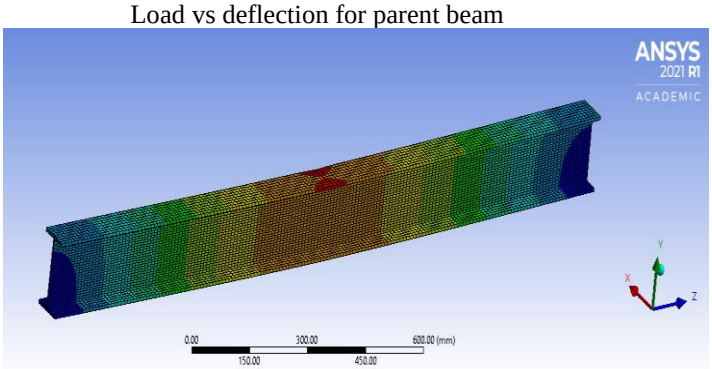
3)The castellated beam of Octagonal openings with Diagonal stiffeners.

4)The castellated beam of Octagonal openings with Ring stiffeners.

[1] Parent beam failure load= 160 KN



Load vs deflection for parent beam



[2] Octagonal castellated beam without stiffener failure load= 190 KN

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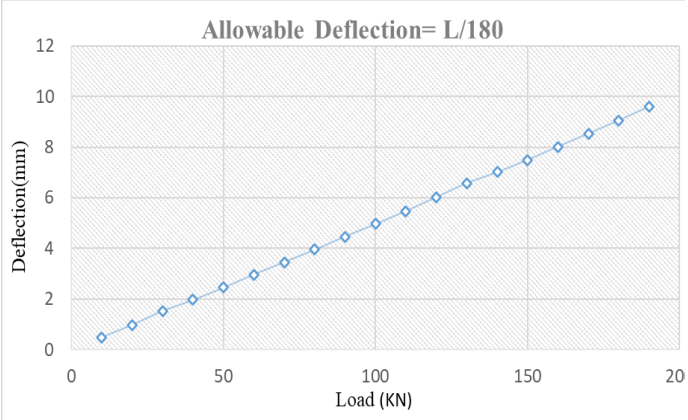
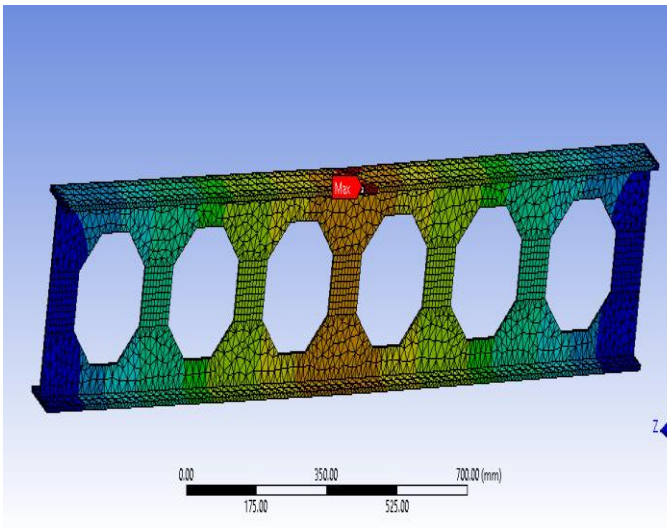
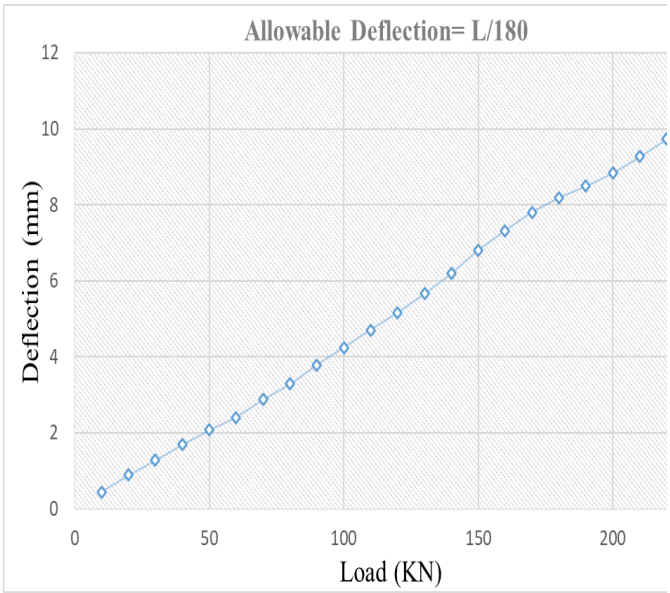


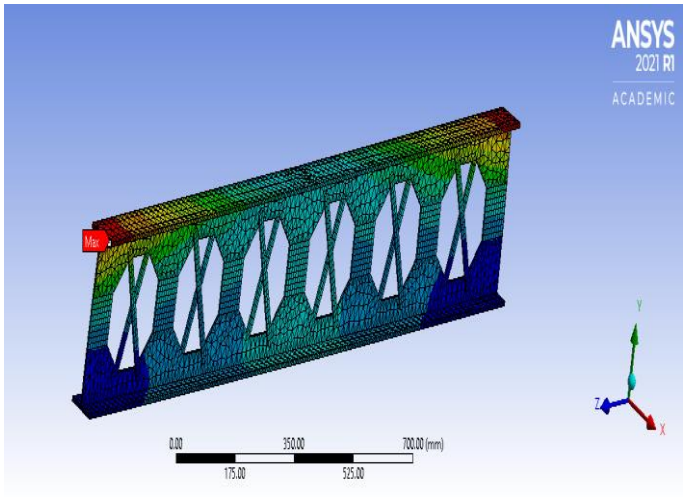
Load vs deflection for castellated beam without any stiffeners.



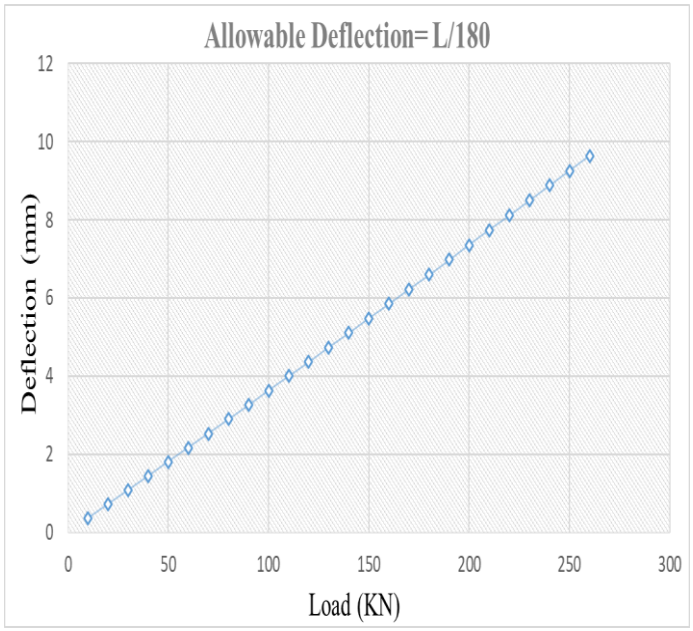
[3] Castellated beam with Diagonal stiffener failure load= 220 KN



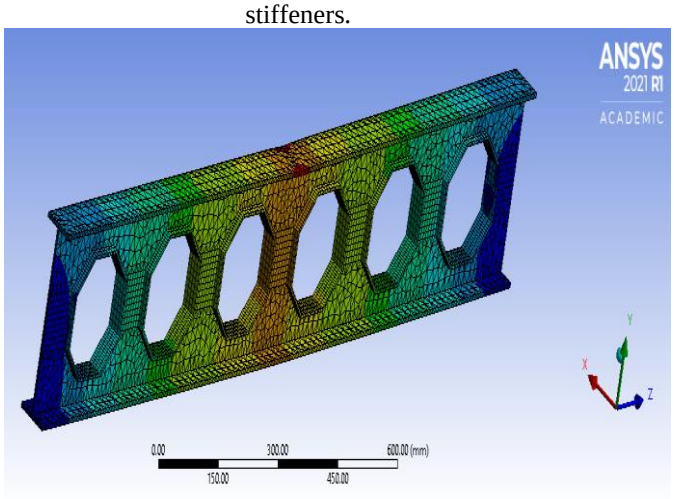
Load vs deflection for castellated beam with diagonal stiffeners.



[4] Castellated beam with Ring stiffener failure load= 260 KN



Load vs deflection for castellated beam with ring stiffeners.



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V. CONCLUSION

[1] The Octagonal castellation process increased the depth of parent beam upto two times.

[2] The allowable load of castellated beam without any stiffener increased upto 119% than that of parent beam.

[3] Also, the allowable load of castellated beams with Diagonal and Ring stiffener increased upto 138% and 163% respectively compared with parent beam.

[4] The Ring stiffener more effective as it carries 18% more load than Diagonal stiffener.

REFERENCES

[1] B. Anupriya and Dr. K. Jagadeesan , "Strength Study on Castellated Beam", International Journal on Engineering Research & Technology, Vol.2, pp 3853-3859. 2013.

[2] P.D.Pachpor, Dr.N.D.Mittal, et.al., "Finite Element Analysis And Comparison Of Castellated & Cellular Beam", Advanced Materials Research, Vol. 264-265, pp 694-699. 2011.

[3] M.R. Soltani , A. Bouchaïr, M. Mimoune , "Nonlinear FE Analysis of the Ultimate Behavior of Steel Castellated Beams",Journal of Constructional Steel Research, vol.70, pp 101-114. 2012.

[4] Gopika S Nair , P.R. Sreemahadevan Pillai, "Castellated Beam with Diagonal Stiffeners Along Hexagonal Cuts", International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, vol.05. 2018.

[5] Hayder W. Al-Thabhawee and Abbas A. Mohammed, "Reinforcing the Octagonal Web Openings of Castellated Beam by Steel Rings",

[6] Wakchaure M. R., Sagade A.V. and Auti V.A., "Parametric Study of Castellated Beam Varying Depth of Web Opening", International Journal of Scientific and Publications, Vol. 2, pp 1-5. 2012.

[7] Sung C. Lee, M. ASCE, Chai H. Yoo and Dong Y. Yoon, "Behavior of Intermediate Transverse Stiffeners Attached on Web Panels", Journal of Structural Engineering, Vol. 128, pp 337-345. 2002.

[8] Jamadar A. M. and Kumbhar P.D., "Parametric Study of Castellated Beam with Circular and Diamond Shaped Openings", International Research Journal of Engineering and Technology, Vol.02, pp 715-722. 2015.

[9] Konstantinos Daniel Tsavdaridis and Grigorios Galiatsatos, "Assesment of Cellular Beams with Transverse Stiffeners and Closely Spaced Web Openings", Thin-Walled Structures, vol.94, pp 636-650. 2015.

[10] Hideo Takabatake, Shigeru Kusumoto and Tomitaka Inoue , "Lateral Buckling Behavior of I Beams Stiffened With Stiffeners", Journal of Structural Engineer, Vol.117, pp 3203-3215. 1991.

[11] Resmi Mohan & Preetha Prabhakaran, "Finite Element Analysis to Compare the Deflection of Steel Beam with and without Web Openings", IOSR Journal of Mechanical and Civil Engineering, Pp.No 7-11, 2016.

[12] Ajim S. Shaikh and Harshal R. Aher, "Structural Aanalysis of Castellated Beam", International Journal on Recent Technologies in Mechanical and Electrical Engineering, Vol.2,pp 081-084. 2015.