UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CORRELATION STUDY BETWEEN PLATE THICKNESS OF PIPE SADDLE SUPPORT AND PIPE LOADING

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**A thesis submitted
in fulfillment of the requirements for the degree of
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2025

DECLARATION

I declare that this thesis entitled “Correlation Study Between Plate Thickness Of Pipe Saddle Support and Pipe Loading“ is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Muhammad Arif Rayhan

Date : 21/10/2025

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Mechanical Engineering

Signature	:
Supervisor Name	: Assoc. Prof Ir. Dr. Mohd Shukri Bin Yob
Date	: 21/10/2025

DEDICATION

To my strongest sister, Chintiyana Rachmaditasari, whose steady support, both emotionally and materially, has been a pillar throughout this journey.

To my beloved mother, Dian Indrasari, who encouraged me every step of the way.

To my sisters, Nafizta Rizcarachmakurnia and Najwa Nazillah, who have always been the ones I turn to when I need to share a story.

To my father, Kotot Rachmana, who never had the chance to witness this moment, but whose spirit and strength carried me through.

ABSTRACT

A piping system is a network of interconnected pipes designed to transport fluids such as liquids, gases, or slurries from one location to another. This method is considered efficient due to its ability to maintain fluid quality without significant loss of properties. The system relies on various fittings and structural components for support, one of which is the pipe saddle support. This component is commonly used to support horizontal steel pipes by transferring the applied loads to adjacent structures and preventing direct contact between the pipe and its base. Stress distribution in pipe saddle supports is often analysed using finite element analysis (FEA). However, this method may yield inaccurate results if the boundary conditions and loading assumptions do not represent actual conditions. Additionally, the absence of experiment validation can lead to inaccurate results leading to problems in the future. Although general standards such as ANSI, ASME, and BS offer guidelines for pipe support systems, they often lack specific design provisions for pipe saddle supports. To address this gap, an oil and gas company which is Petronas developed its own piping support construction standard for large-diameter pipes ranging from 26 to 56 inches in nominal pipe size. Nevertheless, a case was identified in which the actual pipe loading exceeded the allowable limit defined by the standard, suggesting the need for further refinement. To investigate this issue, experiment was conducted on a pipe saddle support subjected to vertical loading. The sample of pipe saddle support is used 1.5 mm thickness. Additionally, the setup featured a portal frame secured using an underground locking system, where a pipe was loaded onto a pipe saddle support sample using a hydraulic system. Stress data were obtained from strain gauges placed at eight points on the flange plate, while the applied load was recorded using a 5-ton capacity load cell. The results indicated that, on average, the pipe saddle support samples failed at an applied load of 16,670.3 N. These experiment results were then used to validate a finite element model, incorporating boundary condition configuration, weld connection modelling, and mesh sensitivity analysis. The boundary condition setup was found to have the most significant effect, with the highest accuracy achieved using an inward contact angle of 11° and a ratio contact angle (R_{ca}) of 0.83, providing an 83.3% accuracy. Using this validated model, a correlation study was conducted to compare pipe saddle supports with sliding, guide, and stopper attachment based on the pipe support construction standard developed by Petronas. The quantitative study concluded that higher pipe loads require thicker saddle plates, with sliding supports requiring the least thickness and stopper supports requiring the most. To further validate the correlation, an additional experiment was performed using a 4.5 mm plate pipe. With the same design and boundary conditions, the FEA achieved an accuracy of 94.6%, demonstrating the suitability of the modelling technique for industrial application. This research offers refined design recommendations that can support fabricators in producing more valid pipe saddle supports for future use.

KAJIAN KORELASI ANTARA KETEBALAN PLAT SOKONGAN PELANA PAIP DAN BEBANAN PAIP

ABSTRAK

Sistem perpaipan merupakan rangkaian paip yang saling berhubung dan direka untuk mengangkut bendalir seperti cecair, gas, atau buburan dari satu lokasi ke lokasi yang lain. Kaedah ini dianggap cekap kerana keupayaannya mengekalkan kualiti bendalir tanpa kehilangan sifat yang ketara. Sistem ini bergantung kepada pelbagai kelengkapan dan komponen struktur untuk sokongan, antaranya sokongan pelana paip yang lazim digunakan bagi menyokong paip keluli mendatar dengan memindahkan beban ke struktur bersebelahan serta mengelakkan sentuhan langsung antara paip dan asasnya. Taburan tegasan dalam sokongan pelana paip sering dianalisis menggunakan kaedah Analisis Unsur Terhingga (FEA), namun keputusan yang diperoleh boleh menjadi kurang tepat sekiranya syarat sempadan dan andaian beban tidak mewakili keadaan sebenar, terutamanya tanpa pengesahan eksperimen. Walaupun piawaian umum seperti ANSI, ASME, dan BS menyediakan garis panduan bagi sistem sokongan paip, ia tidak memberikan perincian khusus untuk reka bentuk sokongan pelana paip. Bagi mengatasi kekurangan ini, Petronas telah membangunkan piawaian pembinaan sokongan paip tersendiri bagi paip berdiameter besar bersaiz nominal antara 26 hingga 56 inci. Namun, terdapat kes di mana beban sebenar paip melebihi had yang ditetapkan oleh piawaian tersebut, menandakan keperluan penambahbaikan. Bagi menyiasat isu ini, ujikaji dijalankan ke atas sokongan pelana paip menggunakan sampel setebal 1.5 mm dengan beban menegak yang dikenakan melalui sistem hidraulik pada rangka portal yang dikunci bawah tanah. Tegasan diukur menggunakan tolok regangan pada lapan titik di plat bebibir, manakala beban direkod dengan sel beban berkapasiti 5 tan. Keputusan menunjukkan kegagalan berlaku secara purata pada beban 16,670.3 N. Data eksperimen ini digunakan untuk mengesahkan model FEA melibatkan konfigurasi syarat sempadan, pemodelan kimpalan, dan analisis sensitiviti jejaring. Ketepatan tertinggi dicapai apabila sudut sentuhan ke dalam ialah 11° dan nisbah sudut sentuhan (R_{ca}) ialah 0.83 dengan ketepatan 83.3%. Berdasarkan model yang disahkan, kajian korelasi dijalankan untuk membandingkan sokongan pelana paip jenis gelongsor, panduan, dan penyekat mengikut piawaian Petronas. Hasil kajian mendapati beban paip yang lebih tinggi memerlukan plat pelana lebih tebal, dengan sokongan gelongsor memerlukan ketebalan paling rendah manakala sokongan penyekat memerlukan ketebalan paling tinggi. Eksperimen tambahan dengan plat setebal 4.5 mm dijalankan untuk pengesahan lanjut, dan dengan reka bentuk serta syarat sempadan yang sama, FEA mencapai ketepatan 94.6%, membuktikan teknik pemodelan ini sesuai untuk aplikasi industri. Kajian ini memberikan cadangan reka bentuk yang lebih terperinci bagi membantu pengilang menghasilkan sokongan pelana paip yang lebih sahih untuk kegunaan pada masa hadapan.

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LIST OF ABBREVIATIONS

ANSI	-	American National Standards Institute
ASME	-	American Society of Mechanical Engineers
BS	-	British Standard
FEA	-	Finite Element Analysis
MIG	-	Metal Inert Gas
NPS	-	Nominal Pipe Size

LIST OF SYMBOLS

ρ	-	Density
σ_y	-	Yield strength
F_a	-	Applied load
R_{ca}	-	Ratio angle of contact
α	-	Inward angle of contact
β	-	Outward angle of contact
T_w	-	Weld thickness
σ_v	-	Von-mises stress
σ_n	-	Normal stress
F_{Axial}	-	Axial load
$F_{Vertical}$	-	Vertical Load
$F_{Lateral}$	-	Lateral force

LIST OF APPENDICES

LIST OF PUBLICATIONS

The followings are the list of publications related to the work on this thesis:

Rayhan, M. A., Shukri Yob, M., Juzaila, M., Latif, A., Munir, A., and Kurdi, O. (2025). Stress Comparison of Pipe Saddle Support Between Experiment and FEA under Vertical Load. *Panamerican Mathematical Journal*, *35*(4s), 10–16. https://doi.org/10.52783/pmj.v35-.i4s.4461. (Published)

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