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LIFTING FRAME FOR TANK ROOF LEG ELEVATION, EMPHASISING USABILITY AND SUSTAINABILITY

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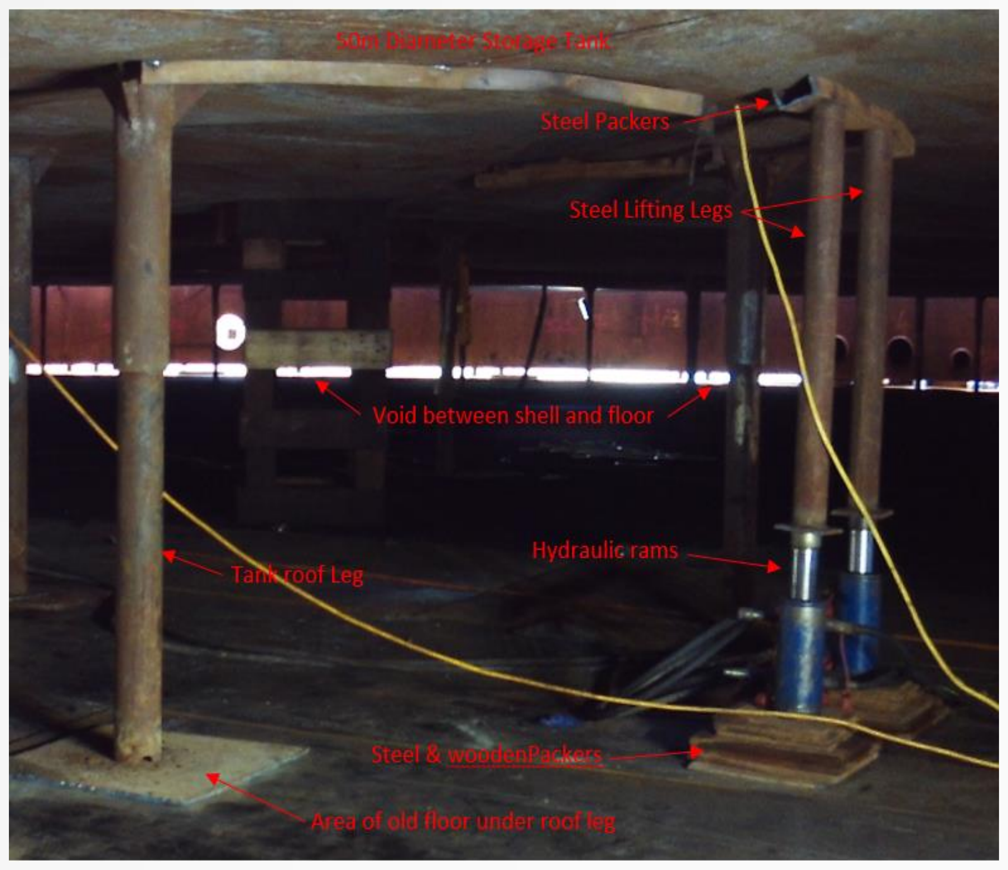
Storage Tank under construction

[redacted]

Storage tanks within the oil and gas industry play a vital role, they can contain unrefined or refined products. The tanks themselves can vary in shape and size, from small cylindrical tanks, spherical tanks, to floating roof tanks some of these large crude tanks can be 50m in diameter and store in excess of 35,000m3 of liquid product

Tank Maintenance

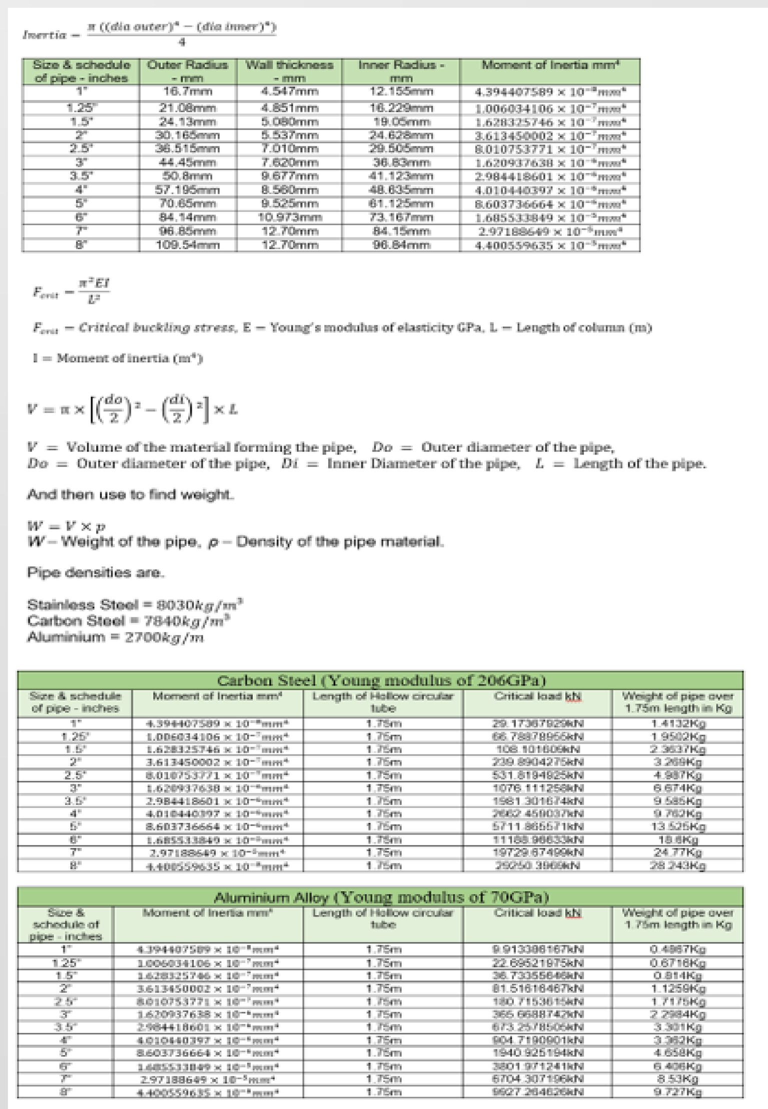


The report will be solely looking at floating roof designed tanks and the maintenance / repair methods used in these tanks after corrosion has taken place and the floor needs replacing. The maintenance procedure for floor replacement is to first cut the shell from the floor, the shell is then raised on jacks creating a void between both surfaces. The corroded floor is then chopped into pieces and slid out of this void. Due to the roof legs being in contact with the floor small areas around the legs cannot be removed at this stage, it is the method of 'lifting the roof legs' (to remove these pieces and lay the new floor) this project aims to improve.

The Problem

During this procedure the steel lifting tubes can 'Bird mouth' (Slide and open) at point of contact with hydraulic jack when under pressure and have in the past caused an uncontrolled release of pressure making the steel lifting tubes and pump move in an uncontrolled manner, becoming projectiles when this happens, it has great potential for harm to users and bystanders

Calculations



$$Inertia = \frac{\pi((dia\ outer)^4 - (dia\ inner)^4)}{4}$$

Size & schedule of pipe - inches	Outer Radius - mm	Wall thickness - mm	Inner Radius - mm	Moment of Inertia mm⁴
1"	16.7mm	4.547mm	12.155mm	$4.394407589 \times 10^{-8} mm^4$
1.25"	21.08mm	4.851mm	16.229mm	$1.006034106 \times 10^{-7} mm^4$
1.5"	24.13mm	5.080mm	19.05mm	$1.628325746 \times 10^{-7} mm^4$
2"	30.165mm	5.537mm	24.628mm	$3.613450002 \times 10^{-7} mm^4$
2.5"	36.515mm	7.010mm	29.505mm	$8.010753771 \times 10^{-7} mm^4$
3"	44.45mm	7.620mm	36.83mm	$1.620937638 \times 10^{-6} mm^4$
3.5"	50.8mm	9.677mm	41.123mm	$2.984418601 \times 10^{-6} mm^4$
4"	57.195mm	8.560mm	48.635mm	$4.010440397 \times 10^{-6} mm^4$
5"	70.65mm	9.525mm	61.125mm	$8.603736664 \times 10^{-6} mm^4$
6"	84.14mm	10.973mm	73.167mm	$1.685533849 \times 10^{-5} mm^4$
7"	96.85mm	12.70mm	84.15mm	$2.97188649 \times 10^{-5} mm^4$
8"	109.54mm	12.70mm	96.84mm	$4.400559635 \times 10^{-5} mm^4$

$$F_{crit} = \frac{\pi^2 EI}{L^2}$$

F_{crit} = Critical buckling stress, E = Young's modulus of elasticity GPa, L = Length of column (m)

I = Moment of inertia (m^4)

$$V = \pi \times \left[\left(\frac{do}{2}\right)^2 - \left(\frac{di}{2}\right)^2\right] \times L$$

V = Volume of the material forming the pipe, Do = Outer diameter of the pipe,
Do = Outer diameter of the pipe, Di = Inner Diameter of the pipe, L = Length of the pipe.

And then use to find weight.

$W = V \times p$
W – Weight of the pipe, ρ – Density of the pipe material.

Pipe densities are.

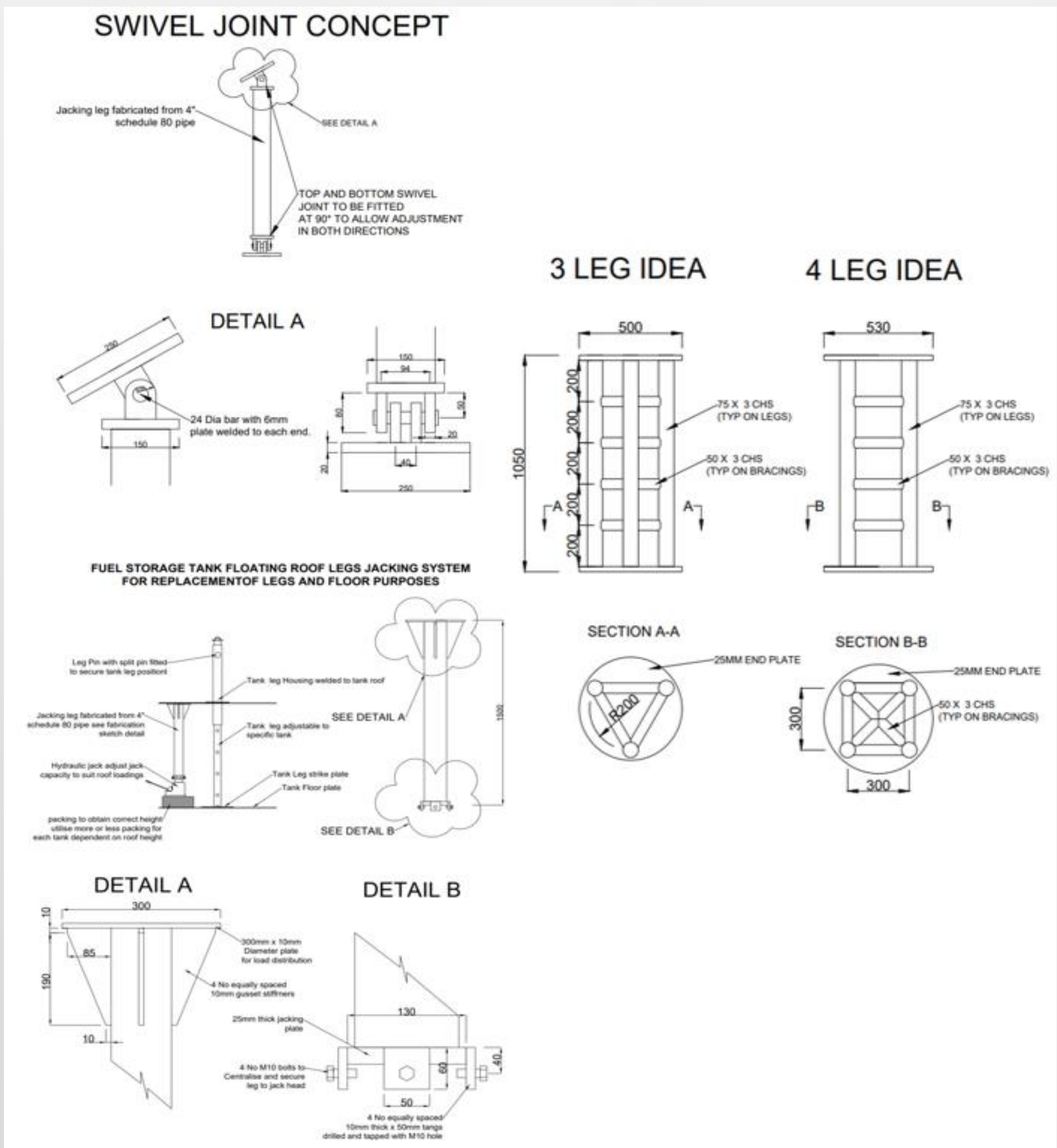
Stainless Steel = $8030 kg/m^3$
Carbon Steel = $7840 kg/m^3$
Aluminium = $2700 kg/m$

Carbon Steel (Young modulus of 206GPa)				
Size & schedule of pipe - inches	Moment of Inertia mm⁴	Length of Hollow circular tube	Critical load kN	Weight of pipe over 1.75m length in Kg
1"	$4.394407589 \times 10^{-8} mm^4$	1.75m	29.17367929kN	1.4132Kg
1.25"	$1.006034106 \times 10^{-7} mm^4$	1.75m	66.78878955kN	1.9502Kg
1.5"	$1.628325746 \times 10^{-7} mm^4$	1.75m	108.101609kN	2.3637Kg
2"	$3.613450002 \times 10^{-7} mm^4$	1.75m	239.8904275kN	3.269Kg
2.5"	$8.010753771 \times 10^{-7} mm^4$	1.75m	531.8194825kN	4.987Kg
3"	$1.620937638 \times 10^{-6} mm^4$	1.75m	1076.111258kN	6.674Kg
3.5"	$2.984418601 \times 10^{-6} mm^4$	1.75m	1981.301674kN	9.585Kg
4"	$4.010440397 \times 10^{-6} mm^4$	1.75m	2662.459037kN	9.762Kg
5"	$8.603736664 \times 10^{-6} mm^4$	1.75m	5711.865571kN	13.525Kg
6"	$1.685533849 \times 10^{-5} mm^4$	1.75m	11188.96633kN	18.8Kg
7"	$2.97188649 \times 10^{-5} mm^4$	1.75m	19729.67499kN	24.77Kg
8"	$4.400559635 \times 10^{-5} mm^4$	1.75m	29250.3969kN	28.243Kg

Aluminium Alloy (Young modulus of 70GPa)				
Size & schedule of pipe - inches	Moment of Inertia mm⁴	Length of Hollow circular tube	Critical load kN	Weight of pipe over 1.75m length in Kg
1"	$4.394407589 \times 10^{-8} mm^4$	1.75m	9.913398167kN	0.4987Kg
1.25"	$1.006034106 \times 10^{-7} mm^4$	1.75m	22.69521975kN	0.6716Kg
1.5"	$1.628325746 \times 10^{-7} mm^4$	1.75m	36.73355646kN	0.814Kg
2"	$3.613450002 \times 10^{-7} mm^4$	1.75m	81.51618467kN	1.1259Kg
2.5"	$8.010753771 \times 10^{-7} mm^4$	1.75m	180.7153615kN	1.7175Kg
3"	$1.620937638 \times 10^{-6} mm^4$	1.75m	365.6688742kN	2.2984Kg
3.5"	$2.984418601 \times 10^{-6} mm^4$	1.75m	673.2578505kN	3.301Kg
4"	$4.010440397 \times 10^{-6} mm^4$	1.75m	904.7190901kN	3.362Kg
5"	$8.603736664 \times 10^{-6} mm^4$	1.75m	1940.925194kN	4.658Kg
6"	$1.685533849 \times 10^{-5} mm^4$	1.75m	3801.971241kN	6.406Kg
7"	$2.97188649 \times 10^{-5} mm^4$	1.75m	6704.307196kN	8.53Kg
8"	$4.400559635 \times 10^{-5} mm^4$	1.75m	9927.264626kN	9.727Kg

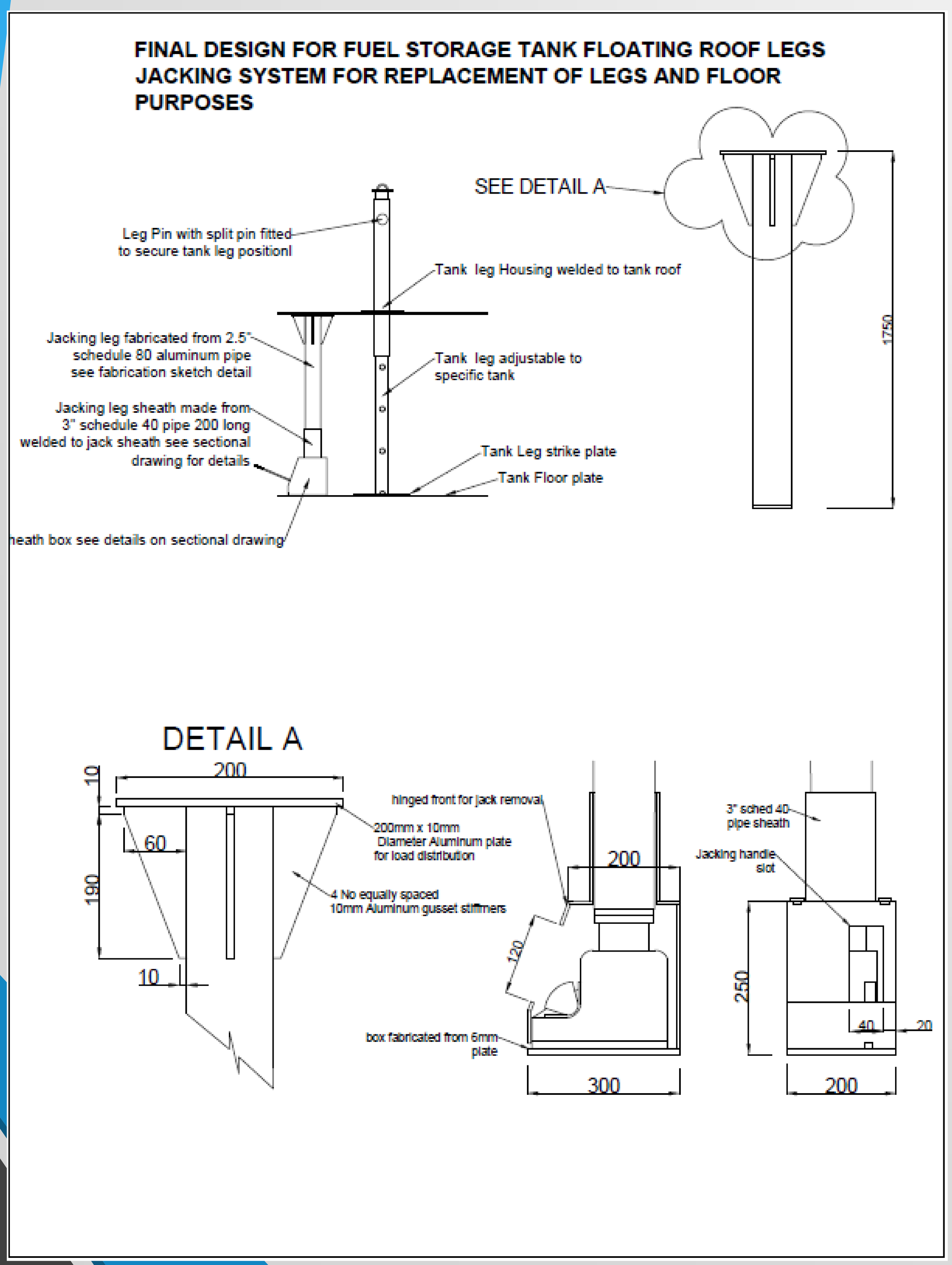
The calculations for tank roof weights were carried out. Jacking beam buckling stresses and material weights were also calculated using T357 Formulae some of which are shown above

Concept CAD Drawings



CAD drawings for initial concept designs were created and are shown above

Final Design



The concept has been refined, indicating the correct materials and size for the jacking post after calculations were conducted. Additionally, a conceptual jack holding system has been drawn this has not been covered during this project, but the need has been realised due to project-specific insights that have emerged during development.