

**STRUCTURAL DESIGN OF A STEEL PLATE COVER TO A
CULVERT AT HOLLINGWORTH ROAD,
LITTLEBOROUGH.**

Project ref: YZ074
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REV.	Revision description	Date
01	First issue	17/04/2024
02	Second issue to capture loads acting on the crown of the pipe & reference guidance from the Standard Conditions for Works Adjacent to Pipelines 90048	21/05/2024
03	Compressible material added to underside of steel plate protection.	10/10/2024

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Vistry Group Bovis Homes Linden HOMES Vistry Partnerships	Project LITTLEBOROUGH CULVERT COVER STEEL PLATE DESIGN			Job No. YZ074
	Drawing Reference	Calculations by HB	Checked by SB	Calc Sheet No. 2
	Unit			Date 10/10/24

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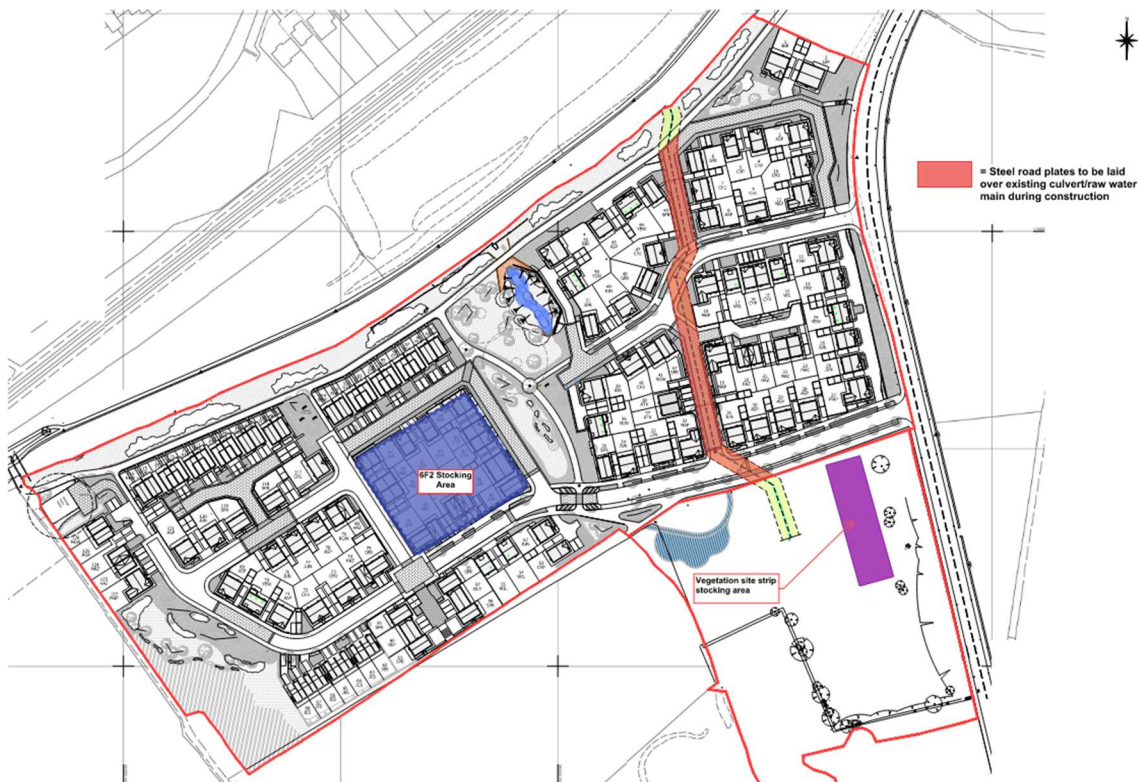
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1. BACKGROUND, DESIGN PHILOSOPHY & ASSUMPTIONS

An existing water main culvert lies within the site boundary (highlighted below in yellow semi-transparent outline). Planning condition 6 for the development highlights the need for the water main to be protected from damage. Mitigation / protective measure are designed within this report by utilizing a steel protective plate with a compressible material underneath over the culvert in areas of vehicle traffic / foreseen surcharge loads.

The steel plate is designed to bridge over both the culvert and the granular surround and redistribute loads to suitable strata either side of the pipe. A layer of compressible material between the steel plate and the granular pipe surround means the only loads acting on the crown of the pipe will be negligible (from the self-weight of granular backfill) and will fall well within the 8.5kN/m² limit set out by clause 4.1.3. of the Standard Conditions for Works Adjacent to Pipelines.

Revision 2

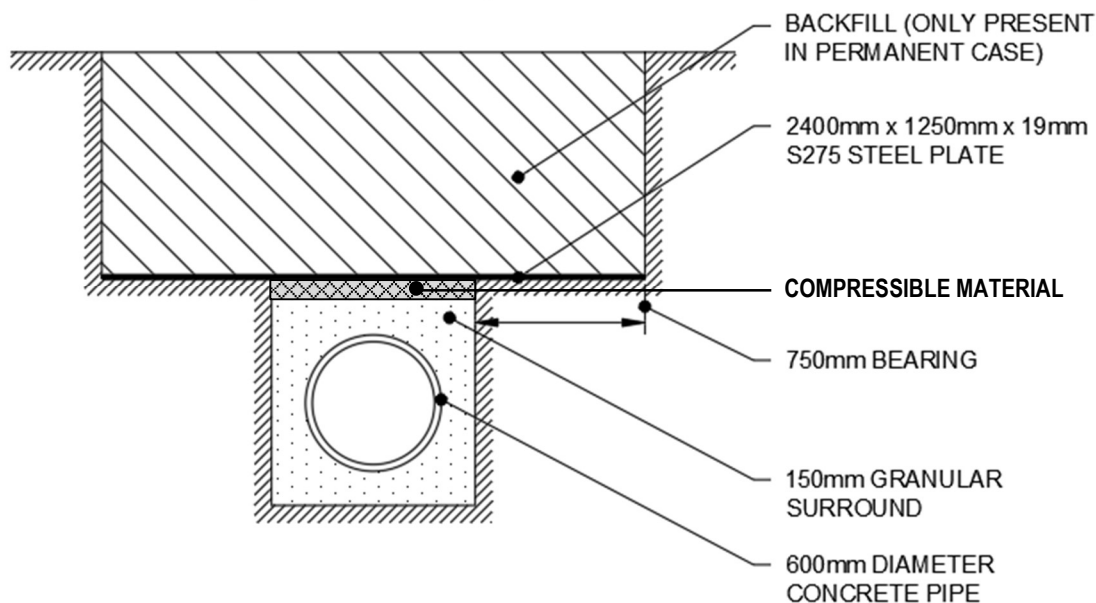


The steel plate cover to the culvert is to be designed to resist both the temporary case (during construction) and the permanent case (completion of the road construction). The more onerous design by inspection is the temporary case because the reduced cover and higher loads from construction vehicles make the intensity of concentrated loads greater.

Due to the low-speed limit on site and the low volume of traffic during the construction phase, load factors attributed to braking, accelerating and centrifugal forces are deemed to be negligible. This risk is to be controlled and managed on site.

The pipe should be bedded and surrounded in appropriate material in the normal way, as shown below:

PARAMETERS USED



In all cases, backfilling should be carried out in accordance with BS EN 1610:2015, clause 11.

Assumptions:

- Concrete pipe of diameter: 600mm.
- Width of granular surround to pipe: 150mm.
- Plate spans a gap of: 900mm.
- Steel grade of plate: S275.
- Plate dimensions: 2400mm x 1250mm x 19mm.
- Compressible material installed between granular surround and underside of steel plate

Design Codes:

- BS EN 1991-2:2023 - Actions on Structures
- NA to BS EN 1991-2:2003 - Actions on Structures
- BS 9295:2020 - Guide to the structural design of buried pipes
- Standard Conditions for Works Adjacent to Pipelines 90048

Revision 2

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	Drawing Reference	Calculations by HB	Checked by SB	Calc Sheet No. 5
	Unit			Date 10/10/24
	2. LOAD CATEGORIES 2.1. LOAD TYPES: Dead loads: Self-weight of plate (accounted for by FEA software): (D1) Live Loads: Vehicle loading (to be determined): (L1) 2.2. LOAD COMBINATIONS: Serviceability Limit State - SLS: 1.00 D1 + 1.00 L1 Ultimate Limit State - ULS: 1.35 D1 + 1.50 L1			

3. LOADINGS

Most onerously loaded plant operating on site (temporary case) & also the most onerously loaded per axle when considering localised concentrated loads:

Circa 40-ton haulage truck (Moxy) such as a Volvo A35G.

OPERATING WEIGHT UNLOADED

			A35G		A40G	
Tires			26.5R25*		29.5R25**	
Front	kg	lb	15,700	34,613	16,100	35,494
Rear	kg	lb	13,600	29,983	14,600	32,187
Total	kg	lb	29,300	64,595	30,700	67,682
Payload	kg	lb	34,500	76,059	39,000	85,980

Operating weight includes all fluids and operator

*) A35G with tires 775/65R25, add 200 kg (440 lb)/axle

**) A40G with tires 875/65R25, add 300 kg (660 lb)/axle

TOTAL WEIGHT

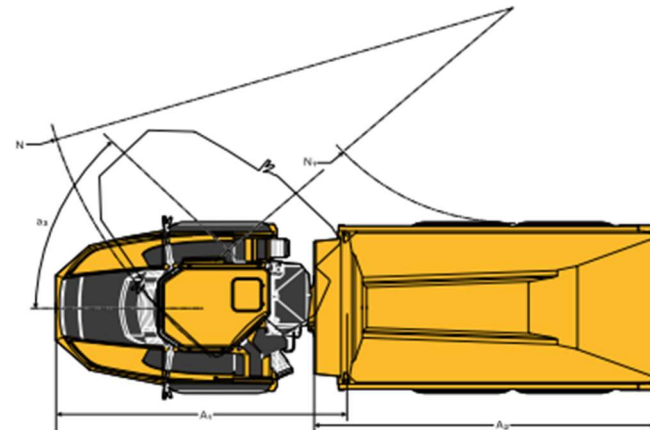
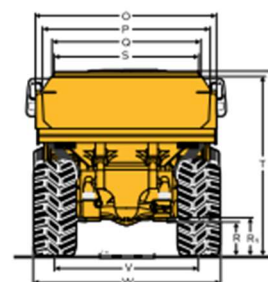
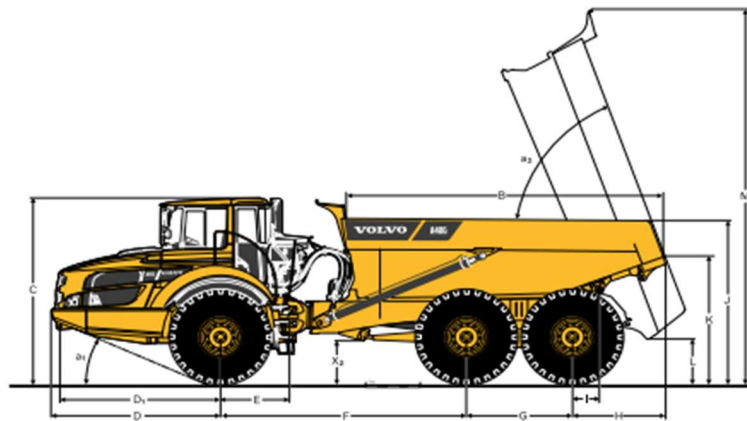
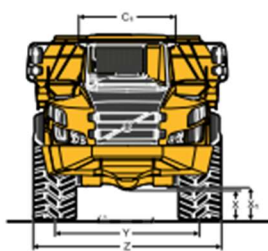
			A35G		A40G	
Tires			26.5R25*		29.5R25**	
Front	kg	lb	19,200	42,329	20,450	45,084
Rear	kg	lb	44,600	98,326	49,250	108,578
Total	kg	lb	63,800	140,655	69,700	153,662

*) A35G with tires 775/65R25, add 200 kg (440 lb)/axle

**) A40G with tires 875/65R25, add 300 kg (660 lb)/axle

GROUND PRESSURE

			A35G		A40G		A35G		A40G	
Tires			26.5R25		29.5R25		775/65R25		875/65R25	
Unloaded										
Front	kPa	psi	132	19.1	111	16.1	115	16.7	98	14.2
Rear	kPa	psi	54	7.8	47	6.8	48	7	42	6.1
Loaded										
Front	kPa	psi	158	22.9	139	20.2	138	20	121	17.5
Rear	kPa	psi	183	26.5	167	24.2	160	23.2	146	21.2



DIMENSIONS

Pos	Unit		A35G		A40G	
A	mm ft in		11,180	36'8"	11,263	36'11"
A ₁	mm ft in		5,476	18'	5,476	18'
A ₂	mm ft in		6,241	20'6"	6,404	21'0"
B	mm ft in		5,568	18'3"	5,844	19'2"
C	mm ft in		3,547	11'8"	3,599	11'10"
C ₁	mm ft in		1,772	5'10"	1,772	5'10"
D	mm ft in		3,100	10'2"	3,100	10'2"
D ₁	mm ft in		2,942	9'8"	2,942	9'8"
E	mm ft in		1,277	4'2"	1,277	4'2"
F	mm ft in		4,578	15'0"	4,518	14'10"
G	mm ft in		1,820	6'	1,940	6'4"
H	mm ft in		1,683	5'6"	1,706	5'7"
I	mm ft in		650	2'2"	495	1'7"
J	mm ft in		3,014	9'11"	3,132	10'3"
K	mm ft in		2,304	7'7"	2,435	8'
L	mm ft in		890	2'11"	822	2'8"
M	mm ft in		7,236	23'9"	7,265	23'10"
N	mm ft in		8,866	29'1"	8,957	29'5"
N ₁	mm ft in		4,416	14'6"	4,327	14'2"
O	mm ft in		3,216	10'7"	3,430	11'3"

DIMENSIONS

Pos	Unit		A35G		A40G	
P	mm ft in		2,902	9'6"	3,118	10'3"
Q	mm ft in		2,553	8'5"	2,820	9'3"
R	mm ft in		564	1'10"	613	2'0"
R ₁	mm ft in		652	2'2"	701	2'4"
S	mm ft in		2,423	7'11"	2,651	8'8"
T	mm ft in		3,382	11'1"	3,427	11'3"
U	mm ft in		3,498	11'6"	3,546	11'8"
V	mm ft in		2,534	8'4"	2,636	8'8"
W	mm ft in		3,221	10'7"	3,403	11'2"
X	mm ft in		500	1'8"	553	1'10"
X ₁	mm ft in		592	1'11"	645	2'1"
X ₂	mm ft in		738	2'5"	788	2'7"
Y	mm ft in		2,534	8'4"	2,636	8'8"
Z	mm ft in		3,221	10'7"	3,403	11'2"
a ₁	°		23.6		24.3	
a ₂	°		72		70	
a ₃	°		45		45	

A35G: Unloaded machine with 26.5R25

A40G: Unloaded machine with 29.5R25

$$\text{Tire width} = W - V = 3221 - 2534 = 687\text{mm}$$

$$\text{Axle load} = 44600 / 2 = 22300\text{kg} (x9.81/1000) = 218 \text{ kN}$$

BS EN
1991-2:
6.3.1

load model 1, which considers Concentrated and uniformly distributed loads, which cover most of the effects of the traffic of lorries and cars. This model should be used for global and local verifications.

BS EN
1991-2
6.3.2(5)

- Each axle of the tandem system should be taken into account with two identical wheels, the load per wheel being therefore equal to $0,5 \alpha Q \times Q_k$.
- The contact surface of each wheel should be taken as square and of side 0,40 m (see Figure 6.2).

In this case the tire width is known to be 0.687m. Using engineering judgement we will assume the same square contact patch.

NA BS EN
1991-2
NA.2.16.1.
3

This square contact area philosophy is further backed up in load model 3 of the National Annex, where: 'the wheel loads of all three SV models should be uniformly distributed over a square contact area as shown in figure NA.1'.

There should be an additional Dynamic Amplification Factor (DAF) applied to account for dynamic effects such as the impact or vibration caused by moving loads.

NA BS EN
1991-2
NA.2

Table NA.2 — Dynamic Amplification Factors for the SV and SOV vehicles

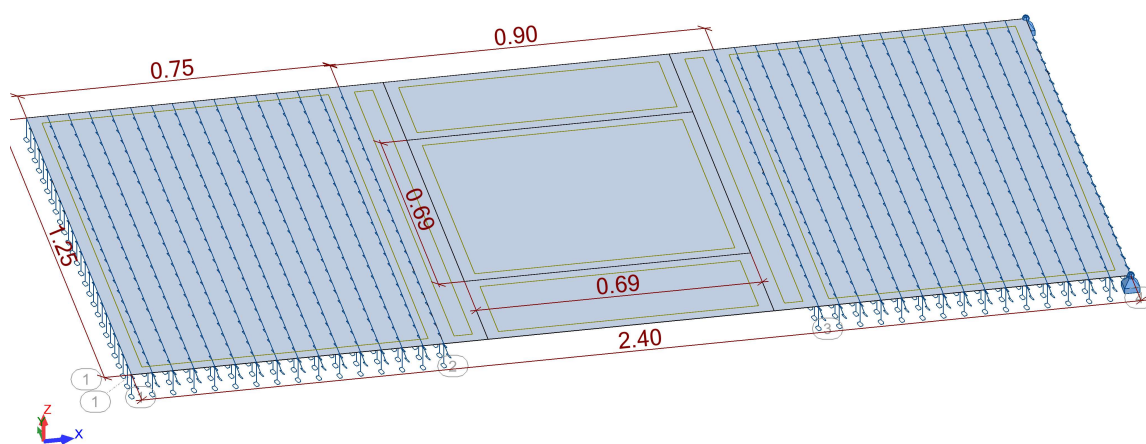
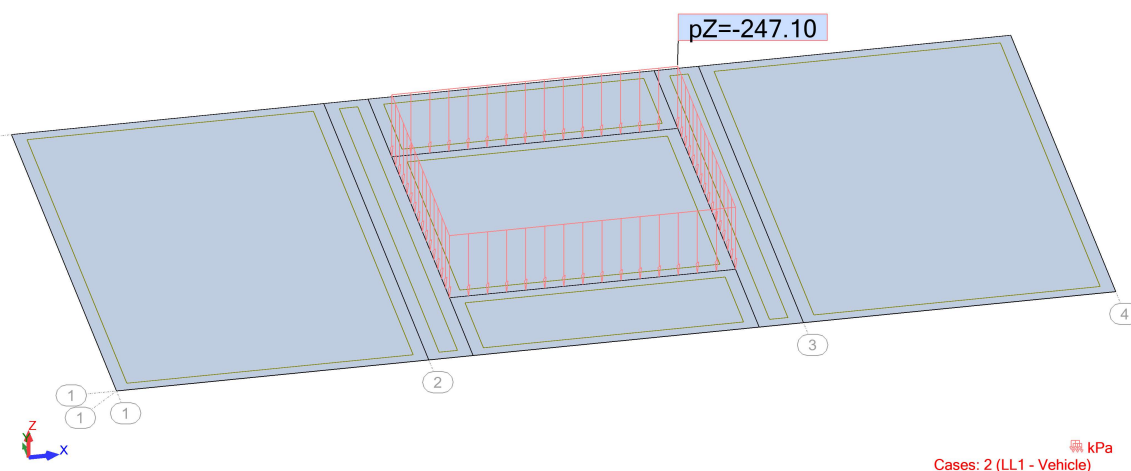
Basic axle load	DAF
100 kN	1,20
130 kN	1,16
165 kN	1,12
180 kN	1,10
225 kN	1,07

$$\text{Basic axle load} = 44600 / 2 \times 9.81 / 1000 = 218 \text{ kN}, \quad \text{Use DAF} = 1.07.$$

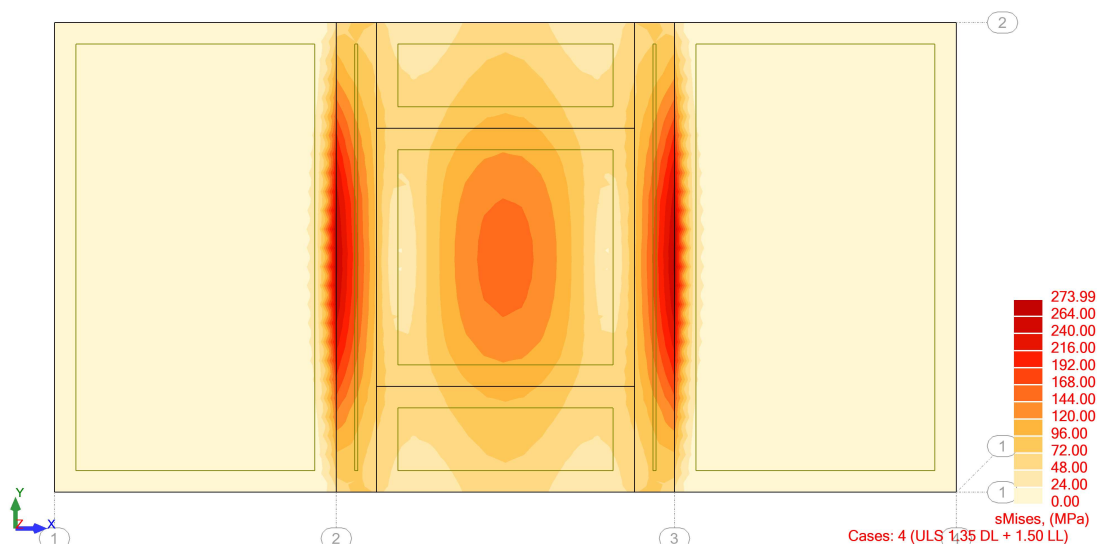
$$\text{load per wheel} = 0,5 \alpha Q \times Q_k.$$

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	Where: $\alpha Q = DAF = 1.07$ $Q_k = 218 \text{ kN}$ Load per wheel = $0.5 \times 1.07 \times 218 = 116.63 \text{ kN (SLS)}$ Area of tire contact on the plate = $0.687\text{m} \times 0.687\text{m}$ Area load acting on this contact patch = $116.63 / (0.687 \times 0.687) = 247.1 \text{ kN/m}^2$				

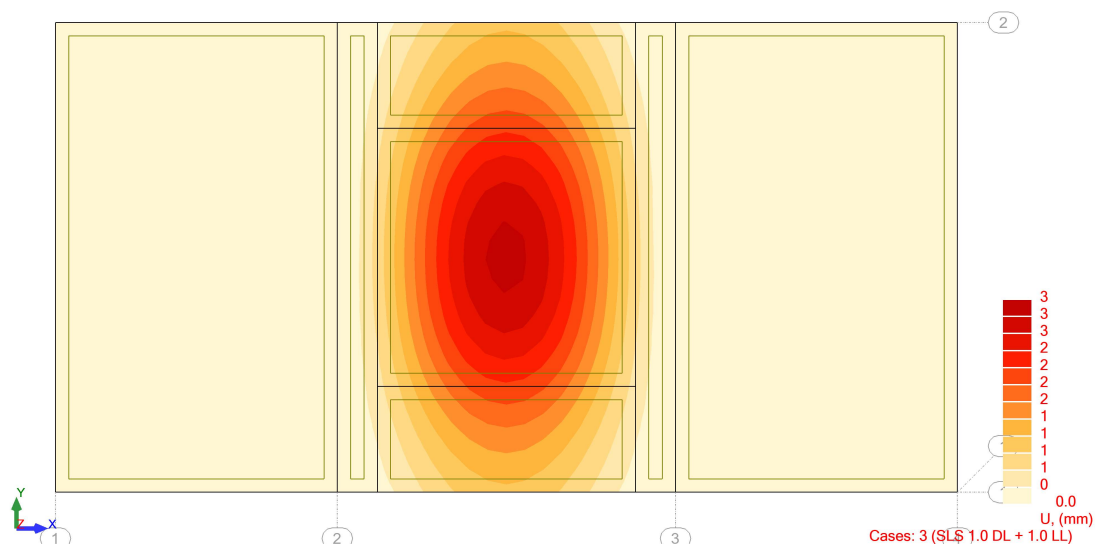
4. ISOMETRIC VIEWS



5. FINITE ELEMENT ANALYSIS



$273.99 \text{ N/mm}^2 < 275 \text{ N/mm}^2$, Therefore PASS
Stresses are within allowable limits.



Consider an allowable deflection = span / 200 for a short spanning structural element with no brittle finishes = $900 / 200 = 4.5 \text{ mm}$

$3 \text{ mm} < 4.5 \text{ mm}$, Therefore PASS
Deflections are within allowable limits.

3mm of deflection should be able to occur without exhausting the limits of the compressible material to ensure no imposed load on the steel plate is distributed to the granular pipe surround underneath. Thus, redistributing loads away from acting on the crown of pipe.

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		Unit			Date 10/10/24
	6. SUMMARY All stresses and deflections are within allowable limits for the steel plate design to resist the most onerous construction traffic loads. The temporary case, designed to resist direct contact with heavy construction vehicles and the steel plate is the most onerous design case. Upon completion of the road construction, the additional cover to the plate as well as the less onerous vehicle loads will result in a less concentrated, distributed load of smaller magnitude. The design is deemed to be <u>satisfactory</u> in its function to protect the main water culvert.				

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