WEHOLITE® MINIMUM COVER WITH APPLICATION OF H20 LIVE LOAD

TECHNICAL BULLETIN

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When live load is not a consideration, the minimum cover over a pipe is generally not a concern. However, when the pipe is subject to live loads, it is necessary to determine what minimum cover is appropriate.

Live loads are not continuous. Live loads are repetitive in nature. In high volume traffic areas, resistance to fatigue may be an issue. When determining the minimum cover that is required, the designer needs to consider that unless the surface is paved (asphalt or concrete), there is a high potential for rutting, especially with wet soils. When rutting occurs, the minimum cover assumed in the design may easily be violated. For all of these reasons, the design for 'minimum cover' should be very conservative.

Several analysis techniques have been assessed in the determination of the 'minimum cover required with Weholite® pipe when live loads are considered. Three 'models' were considered in the assessment. They are:

1. Watkin's original model for assessment of shallow cover (considers pipe acting alone)
2. Watkins later model for assessment of shallow cover (includes contribution of soil in resisting live loads).
3. A linear elastic FE analysis (ROR) developed for KWH Pipe.

1. Watkins' original model[1]

The analysis for determination of minimum cover requirements is based on the assessment of cohesionless soils only. Traffic is seldom placed on cohesive soils. Vehicles get stuck in the mud.

Cohesionless soils offer little or no support to the live loads. Only the pipe carries the live loads. However the soil does act to disperse the tire pressure felt at grade. The live load pressure acting at the top of the pipe decreases with increases in cover.

To determine the 'minimum cover', the worst case live loading condition of a tire pressure acting to one side of center line is considered. The location of maximum moment is computed to be at about 12° to the opposite side of centerline based on Castigliano's equation. The minimum cover is based on the capacity of the pipe wall acting alone to resist the bending moment at this location.

2. Watkins' later model[2]

Soil pressure at the crown of the pipe can be supported by the pipe's flexural stiffness and the soil's resistance against upheaval. Pipe material properties may be based on the anticipated 'short term' load duration. The factor of safety associated with a given combination of load geometry and pipe material properties can be computed. The model is based on application of a point live load directly above the centerline of the pipe.

The PPI Engineering Handbook, 2nd Edition (Chapter 6) includes a detailed description of this model for the assessment of shallow cover burial loads.

[1] Structural Mechanics of Buried Pipe, Watkins & Anderson, CRC Press.
[2] Watkins , R.K. (1977), Minimum Soil Cover Required Over Buried Flexible Cylinders, Interim Report, Utah State University, Logan, UT.

<ins>3. ROR FE Analysis</ins>

Another assessment was made using ROR99 .. a linear elastic FEA model that determines the stress level in the pipe caused by soil loads and live loads. No factor of safety is applied when using this analysis tool. Instead pipe wall stresses and deflections are calculated. The designer is to determine if the predicted deflections and stress levels are acceptable. The live load is applied at the center-line of the pipe.

This model allows the user to specify the location of the live load. It was determined that the most critical live load location occurred when the live load is placed at centerline.

For this assessment three pipes were selected for a comparative review. They were 48 RSC 160, 72 RSC 250 and 108 RSC 400.

COMMENTARY:

When considering the acceptable minimum cover, the designer is cautioned to consider the possibility that shallow cover may be insufficient to resist flotation forces when the water table is above the pipe. The pipe may well ‘pop out of the ground’. The assessment of various ‘shallow burial’ models ignores that possibility.

All three models were used to determine the depth of cover associated with selected values of wall stress. The wall stress values used were 5 Mpa (725 psi), 1,000 psi, 2,000 psi and 3,000 psi. In some cases it was not possible to ‘reach’ the higher values of wall stress. Stress increases induced by live load with a decrease in cover, were offset by decreases in stress as the dead load was removed.

ASSESSMENT:

Based on an assessment of these analyses tools, KWH Pipe has decided to produce a table of ‘Minimum Cover’ values based on Watkin’s early model when applying a FS of 2.5 applied to the case of pipe wall stress associated with long duration loads (1,000 psi).

Although use of the stress level associated with long duration loads may be considered to be a conservative assumption, it should be noted that long term stress levels have been shown to be sufficient to cause failure in cyclic loading situations.

The minimum cover values in the table are for a pipe in an unpaved roadway. The notes to the table provide advice to the user about the reduction in minimum cover that is possible if the road is paved with either asphalt or concrete pavement.

Soil Cover Height vs Max'm Pipe Wall Stress

	Pipe Wall Stress (psi)	Pipe Size & Stiffness 48/160 (m)	72/250 (m)	108/400 (m)
Watkins Early Model	725	0.62	0.58	1.04
	1000	0.50	0.44	0.83
	2000		0.22	0.49
	3000		0.12	0.34
PPI Chapter 6, Shallow Cover	725	0.62	0.72	1.16
	1000	0.50	0.62	1.09
	2000			0.88
	3000			0.67
ROR FEA	725	0.90	0.75	0.81
	1000	0.65	0.58	0.59
	1500	0.43	0.40	0.35
	2550	0.26	0.17	

Weholite v1.25				
Minimum Cover (inches)				
Nom Size	RSC			
	100	160	250	400
18		15.8		
19.5		19.8		
21		21.5		
24		21.7		
27		21.9		
30		23.2		
33		25.2	19.8	
36	30.5	32.4	23.3	
40	35.4	32.6	25.2	
42	44.7	34.6	26.0	
48	44.8	34.9	26.8	
54	47.7	36.9	29.0	
60	48.7	39.7	31.2	
66	50.2	39.7	33.1	
72	54.0	42.5	35.2	
78	54.1	45.0	35.2	
84	54.2	45.1	36.9	
90	57.1	45.2	36.9	29.1
96	57.2	47.2	37.7	30.3
102	60.5	51.4	38.7	33.1
108	60.6	51.7	40.6	33.3
120	63.5	51.9	42.2	35.2
132		52.1	46.3	

Notes

1. The methodolgy used to determine the minimum cover required above the top of pipe, is that which is described in the 'Structural Mechanics of Buried Pipe', by Watkins and Anderson. The 'minimum cover' is determined by assuming no support is offered by the soil cover over the pipe, although the soil cover acts to disperse the live load pressure, and then determining what live load could be supported by the bending moment resistance of the pipe when the load is placed eccentric to centerline (the worst case scenario).

2. The values in the table were obtained using an induced pipe wall stress of 1,000 psi and a factor of safety of 2.5. The allowable short term stress for PE is significantly higher than 1,000 psi. However, traffic loading is often cyclic in nature and this mathematical model does not consider cyclic loadings. The use of the lower allowable long term stress value in combination with a high factor of safety provides a hgih degree of assurance against failure due to the cyclic loadings associated with vehicular traffic.

3. If asphalt or concrete pavement is used over the pipe, the minimum cover can be reduced by the thickness of the asphalt layer, or reduced by twice the thickness of the concrete layer. For example, the minimum cover with embedment materials taken to grade on a 72 RSC 160 is 42.5". With 6" asphalt, the minimum cover would be 36.5"; and with 6" concrete pavement, the minimum cover would be 30.5".

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