Better Understanding Of The Intent of AS/NZS 3725:2007 – Case Study

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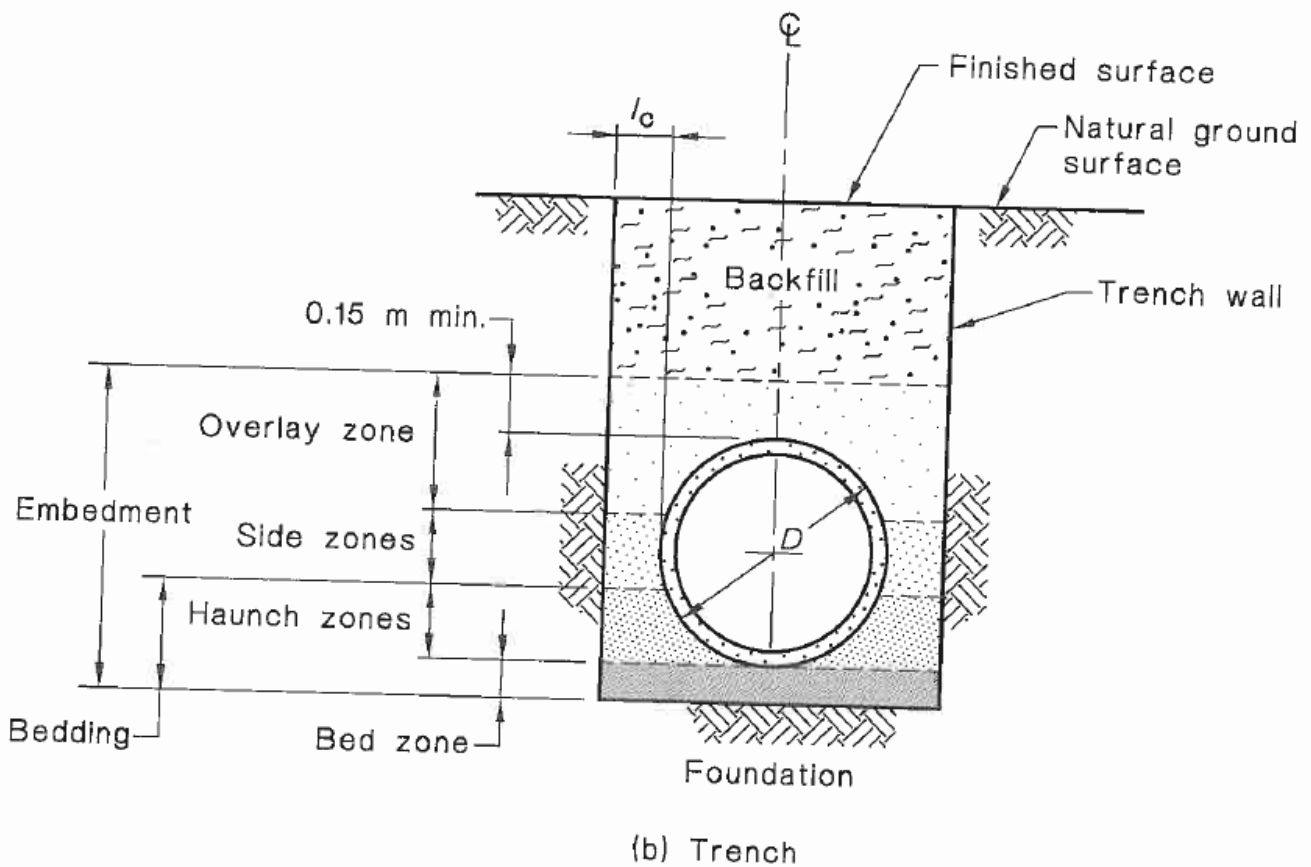
Main Messages

- AS/NZS3725- aims to work in all natural ground conditions
- “bullet proof” solution.
- Compliant more economical solutions are available if understand background of AS/NZS3725.
- AS/NZS 3725 allows alternative materials.
- Refer- CPAA “Guidelines for selecting Materials for bedding SRC pipes.”

Terminology



(b) Trench

FIGURE 1 FILL AND PIPE SUPPORT TERMS

AS/NZS 3725:2007

- Specifies bedding materials with certain grading limits.
- Grading carefully selected to achieve the following:
  1. Good haunch and side support for all pipe size range.
  2. Ease of compaction.
  3. Long term stability by not allowing migration of fines.

This relieves the Designers and Installers of the need to *investigate the suitability* of the bedding material to their specific application.

Potential issues with this approach

- Specifiers and Contractors have difficulties in supplying AS/NZS3725 materials at feasible cost.
- Constructors prefer to use open graded (free draining materials) suitable to the wet conditions of New Zealand.

AS/NZS 3725:2007 allows alternatives

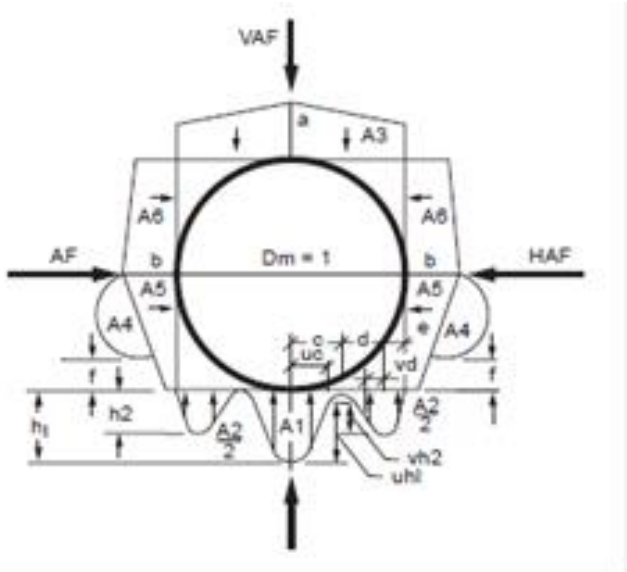
"this standard shall not be interpreted so as to prevent the use of materials or methods of design or construction not specifically referred to herein, provided that such materials or methods can be shown to meet the intent of this Standard".

An explanation the intent of AS/NZS3725

1. Referring to pipe bedding theories
2. Reviewing International Standards (ACPA, ASTM, BSI, EN)
3. Reviewing AS/NZS flexible pipe standard and AS/NZS 3725:2007 commentary
4. Presenting a case study where analysis of pipe installation indicates that alternative materials can meet the intent of the Standard.

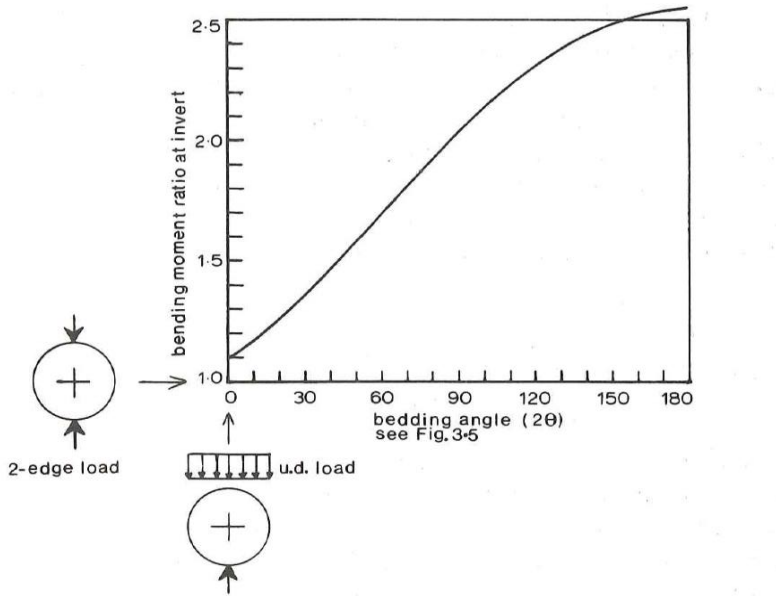
Pipe bedding theories

ACPA -Heger Earth Pressure Distribution



- Soil in those portions of the bedding and haunch areas directly under the pipe is difficult to compact.
- The soil in the haunch area from the foundation to the pipe springline provides significant support to the pipe and reduces pipe stresses.

Theoretical Bedding Factors from Theory of Elasticity



Full theoretical value is achievable if bedding material at the bed and haunch zones are well compacted and uniformly support the pipe.

AS/NZS 3725:2007 STANDARD BEDDING MATERIALS

Grading Limits of Materials for Bed and Haunched Zone

Sieve size (mm)	19.0	2.36	0.60	0.30	0.15	0.075
Weight passing %	100	100-50	90-20	60-10	25-0	10-0

Grading Limits of Materials for Side Zone

Sieve size (mm)	75.0	9.5	2.36	0.60	0.075
Weight passing %	100	100-50	90-20	60-10	25-0

1. *Bedding factors should be reduced to 1.5 for both H and HS supports if the bed and haunch zones materials have a fraction passing the 0.6 mm sieve outside the specified limit, and not otherwise cement stabilized.*
2. *Any maximum bedding factors should be reduced by 15% if the grading of the bed and haunch zones materials fell outside the limits of other sieve sizes.*

Four intentions of these restrictive grading's

1. Good side and haunch support (bedding factors)
2. Stability in wet conditions (avoiding clay)
3. Compatibility around pipe (max agg size)
4. Migration of fines

What 3725 achieve by specifying bedding materials grading

1- Good haunch and side support

AS/NZS 3725:2007 Bedding Factors

Support Type		Minimum depth, mm		Minimum zone compaction, %			Bedding factor (*BF*)
		Bed zone x	Hunch zone y	Bed and hunch zones *ID*	Side zones		
					ID	*RD*	
U		75					1.0
H	H1	100 if D < 1500; or 150 if D > 1500	0.1D	50			1.5
	H2		0.3D	60			2.0
HS	HS1	100 if D < 1500; or 150 if D > 1500	0.1D	50	50	85	2.0
	HS2		0.3D	60	60	90	2.5
	HS3		0.3D	70	70	95	4.0

- **Full theoretical value is achievable if bedding material at the bed and haunch zones are well compacted and uniformly support the pipe.**

Required for 3725 H1 and H2

But in practice:

- **Soil in those portions of the bedding and haunch areas directly under the pipe is difficult to compact.**

Not Required for International Standards HS

2 - Stability in Saturated Conditions

- **Cohesive materials have very high shear strength when dry**
- **Available as local excavated material from trenches or cut to fill embankments.**
- **Attractive option for pipe support**
- **However, they lose most of their strength when saturated.**
- **ACPA and AS/NZS 2566 accept them on condition of higher compaction and lower bedding factors**

Installation Type	***Bedding Thickness***	***Haunch and Outer Bedding***
Type 1	*Do/24 minimum, not less than 75 mm (3"). If rock foundation, use Do/12 minimum, not less than 150 mm (6").*	*95% Category I*
Type 2	*Do/24 minimum, not less than 75 mm (3"). If rock foundation, use Do/12 minimum, not less than 150 mm (6").*	*90% Category I or 95% Category II*
Type 3	*Do/24 minimum, not less than 75 mm (3"). If rock foundation, use Do/12 minimum, not less than 150 mm (6").*	*85% Category I, 90% Category II, or 95% Category III*
Type 4	*No bedding required, except if rock foundation, use Do/12 minimum, not less than 150 mm (6").*	*No Compaction required, except if Category III, use 85% Category III*

Soil Type	***Representative Soil Type***	
	Unified Soil Classification	***Standard AASHTO***
Gravelly Sand *(Category I)*	*SW, SP, GW, GP*	*A1, A3*
Sandy Silt *(Category II)*	*GM, SM, ML, Also GC, SC with less than 20% passing #200 sieve*	*A2, A4*
Silty Clay *(Category III)*	*CL, MH, GC, SC*	*A5, A6*

Pipe Diameter	Standard Installation			
	Type 1	Type 2	Type 3	Type 4
300	4.4	3.2	2.5	1.7
600	4.2	3	2.4	1.7
900	4	2.9	2.3	1.7
1500	3.8	2.8	2.2	1.7
3600	3.6	2.8	2.2	1.7

EMBEDMENT AND NATIVE SOIL—MATERIALS AND MODULI*

Materials			Moduli E'_e and E'_n MPa				
Description	Classification		Uncompacted	R_D (%)			
				85	90	95	100
				I_D (%)			
				50	60	70	80
	AS 1726 †	AS 2758.1	Standard penetration test ‡ Number of blows				
			≤ 4	> 4 ≤ 14	> 14 ≤ 24	> 24 ≤ 50	> 50
Gravel— single size	—	Coarse aggregate	5§	7§	7§	10§	14
Gravel— graded	GW		3§	5§	7§	10§	20
Sand and coarse-grained soil with less than 12% fines	GP, SW, SP and GM-GL, GC-SC etc.	—	1	3§	5§	7§	14
Coarse-grained soil with more than 12% fines	GM, GC, SC SM and GM-SC, GC-SC	—	NR	1§	3§	5§	10
Fine-grained soil (LL<50%) with medium to no plasticity and containing more than 25% coarse-grained particles	CL, ML, mixtures ML-CL and ML-MH	—	NR	1§	3§	5§	10
Fine-grained soil (LL<50%) with medium to no plasticity and containing less than 25% coarse-grained particles	CI, CL, ML, mixtures ML-CL, CL-CH and ML-MH	—	NR	NR	1	3	7
Fine-grained soil (LL>50%) with medium to high plasticity	CH, MH and CH-MH	—	NR	NR	NR	NR	NR

AS/NZS 3725 alternative bedding materials

To assure stability in all conditions and compactability:

- **AS/NZS 3725:2007 specifies that bedding materials shall contain limited quantities of fine plastic materials.**
- **Otherwise, be cement stabilized to maintain stability in saturated conditions and improve compactability.**

3- Compactability Maximum Size of Aggregates

DIN EN 1610

- **22 mm for DN 200 mm and less**
- **40 mm for DN 200 – 600 mm**
- **60 mm for DN > 600 mm**

IGN 4-08-01 (UK WIR 1994)

- **10, 14, or 20mm (Single size or graded down to 5mm) for DN 150 to 300mm**
- **14 or 20mm (Single size or graded down to 5mm) for DN 300 – 550mm**
- **14, 20, or 40mm (Single size or graded down to 5mm) for DN > 550mm**

AS/NZS 3725:2007

Sieve size (mm)	19.0	2.36	0.60	0.30	0.15	0.075
Weight passing %	100	100-50	90-20	60-10	25-0	10-0

4- Migration of Fines

Pipeline bedding can be effected by migration of fines by one or more of the following:

1. **Contamination of bedding materials with plastic cohesive fine materials affects long term stability of the installation when wet.**
2. **Migration of fines from pipe bedding cause loss of support to pipe and overloading.**
3. **Migration of fines from side soil can cause loss of support to top or adjacent structures.**

Testing for Compatibility

a) D15/d85 < 5,

b) D50/d50 < 25, This criterion need not apply where the coarser material is well graded (see AS 1289.3.6.1).

Alternatively -

4- Migration of Fines

Where the finer material is a medium to highly plastic clay *(CL or CH),* then the following criterion may be used in lieu of the D15/d85 criteria:

D15 < 0.5 mm **where D15 is the sieve opening size passing 15% by weight of the coarser material.**

4- Migration of Fines AS/NZS3725 approach

- **AS/NZS 3725:2007 uses an approach of specifying a material grading that suitable to restrict migration of fines when used with all *types of soils including plastic clay:***
- AS/NZS 3725 uses the next available sieve size in Australian Standard of ***0.6mm*** as its governing guide to achieve this criteria.
- It specifies that **D20<0.6** to make sure that ***all bedding materials will achieve the filter criteria***.
- Outside 3725 grading limit = Not stable for any site condition and reduces the BF to a minimum of 1.5.

Alternatives to achieve

1. Good side and haunch support (bedding factors)
2. Stability in wet conditions (avoiding clay)
3. Compatibility around pipe (max agg size)
4. Migration of fines

Where we have some knowledge of the ground conditions and available material

ENGINEERING GUIDELINE

Selecting Materials for Bedding Steel Reinforced Concrete Pipe

Concrete Pipe Association of Australasia

OPTION 1- CPAA ENGINEERING GUIDELINES

Table B

MINIMUM COMPACTION REQUIREMENTS FOR VARIOUS BEDDING TYPES AND SELECT FILL SOIL CLASSES

Bedding Type	HS3		HS2		HS1		H2		H1	
Bedding Material	I_D	R_D	I_D	R_D	I_D	R_D	I_D	R_D	I_D	R_D
SW, SP, GW, GP	70	95	60	90	50	85	60	90	50	85
SC, GC	n/a	n/a	70	95	60	90	70	95	60	90

NOTES: 1. I_D refers to Density Index (%) and is for cohesionless materials (refer to Clause 8, AS/NZS 3725 for more information).
2. R_D refers to Dry Density Ratio (%) and is for cohesive materials (refer to Clause 8, AS/NZS 3725 for more information).

a) Use clean granular materials free from cohesive plastic soils

b) Achieve Compaction

b) Test compatibility or use methods to prevent migration of soil fines

c) Long thin particles are not used

d) Maximum particle size selected to ensure uniform support around the pipes

***Alternatively**, if a) to d) inclusive cannot be achieved, the bedding material must be cement stabilized.*

OPTION 1- CPAA ENGINEERING GUIDELINES

Table C

RECOMMENDED MAXIMUM PARTICLE SIZE (mm)

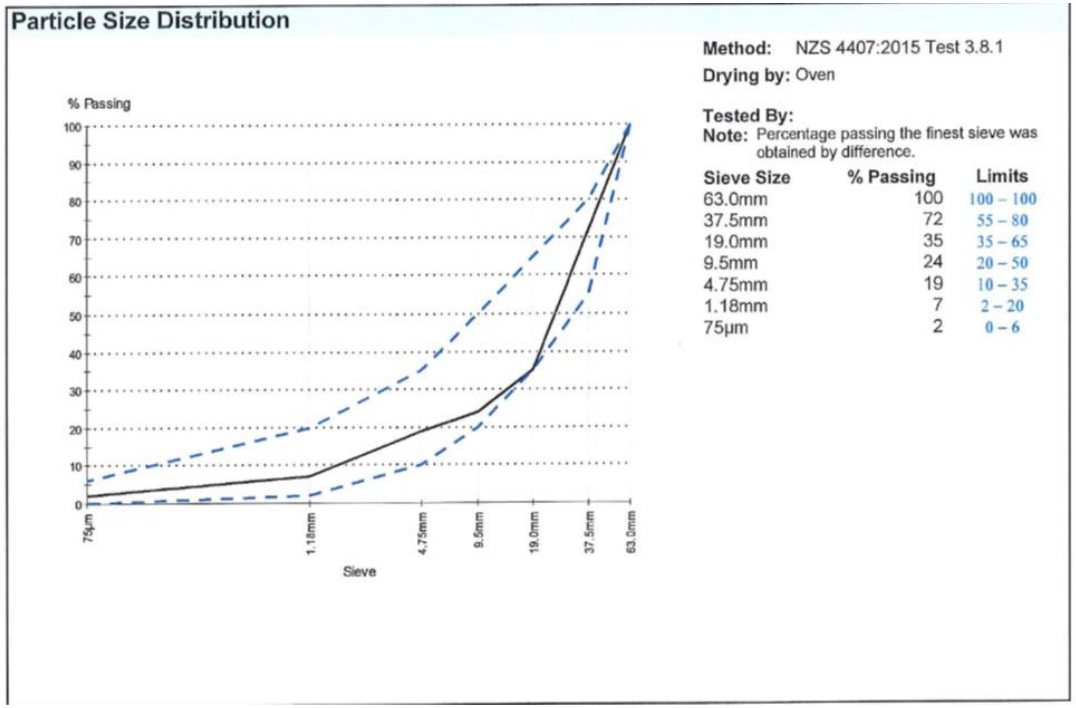
Pipe diameter	Bedding Zone	
DN	Bed and Haunch	Side
225- 1350	20	40
1500 - 2250	40	75
> 2250	65	75

NOTES: If the requirements for the above recommendations are met, the bedding factor reduction outlined in AS/NZS 3725 Clause 9.3.2will not apply. However, as in accordance with AS/NZS 3725 Clause 9.3.3, bedding factors will be reduced in line with the Standards recommendations if the conditions prescribed for the use of these materials cannot be demonstrated or achieved.

OPTION 2 REDUCED BEDDING FACTOR (PROPOSED FOR HS BEDDING)

- **BF = 4** **for Standard materials compacted to 95% relative compaction**
- **BF = 2.5 – 3.4** for:
  1. **Granular materials outside the grading limit.**
  2. **Low risk of contamination with plastic fine cohesive materials, and**
  3. **Bedding materials compacted to 95% relative compaction.**
- **BF = 2.0- 2.5** for:
  1. **Granular materials outside the grading limit.**
  2. **Higher risk of contamination with plastic fine cohesive materials.**
  3. **Bedding materials compacted to 95% relative compaction.**
- **BF = 1.5** when:
  1. **Bedding materials is not compatible with surrounding soil.**
  2. **Flowing ground water conditions and**
  3. **No measures to control movement of fines are taken.**

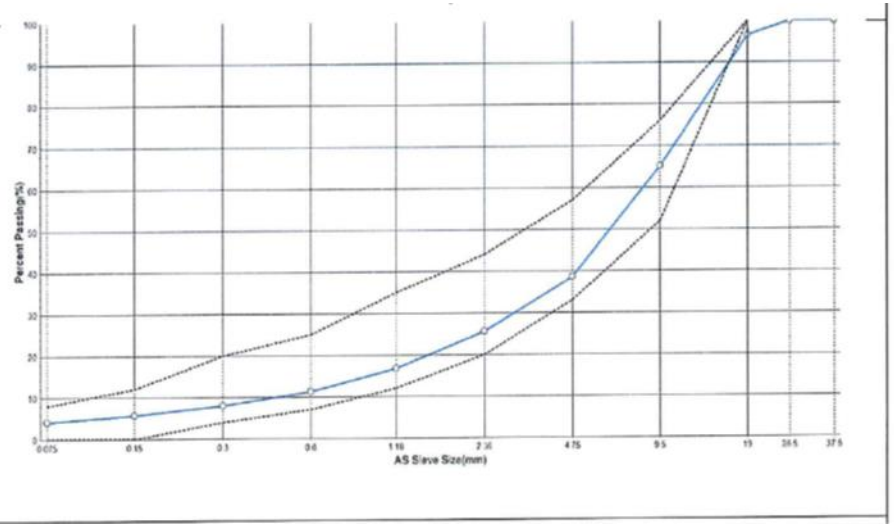
CASE STUDY



Example of Particle Size Distribution of GAP 65 used in bedding

Remarks

AS Sieve Size(mm)	Percent Passing	Specification Limits (% Passing)
75		
63		
53		
37.5	**100**	
26.5	**100**	
19.0	**97**	100-100
serhead_notes		
13.2		
9.5	**65**	52-76
6.7		
4.75	**39**	33-57
2.36	**26**	20-44
1.18	**17**	12-35
0.600	**11**	7-25
0.425		
0.300	**8**	4-20
0.150	**6**	0-12
0.075	**4**	0-8



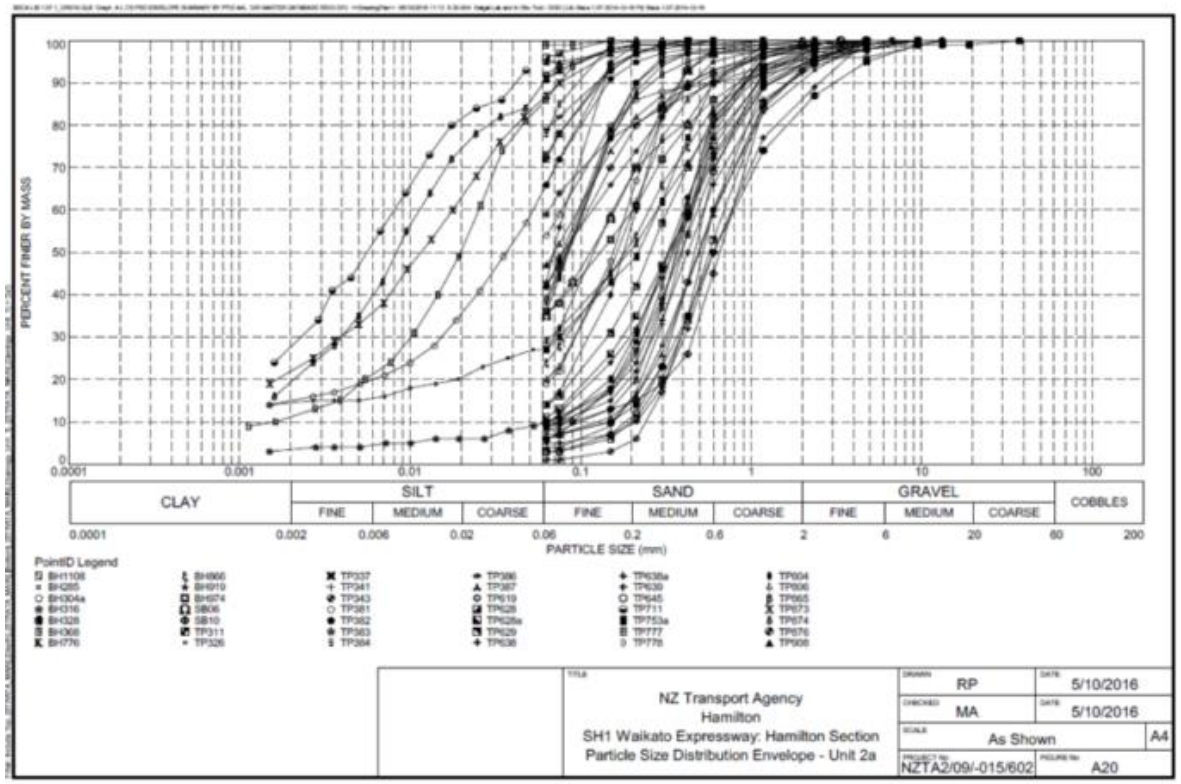
Example of Particle Size Distribution of GAP 30 used in bedding

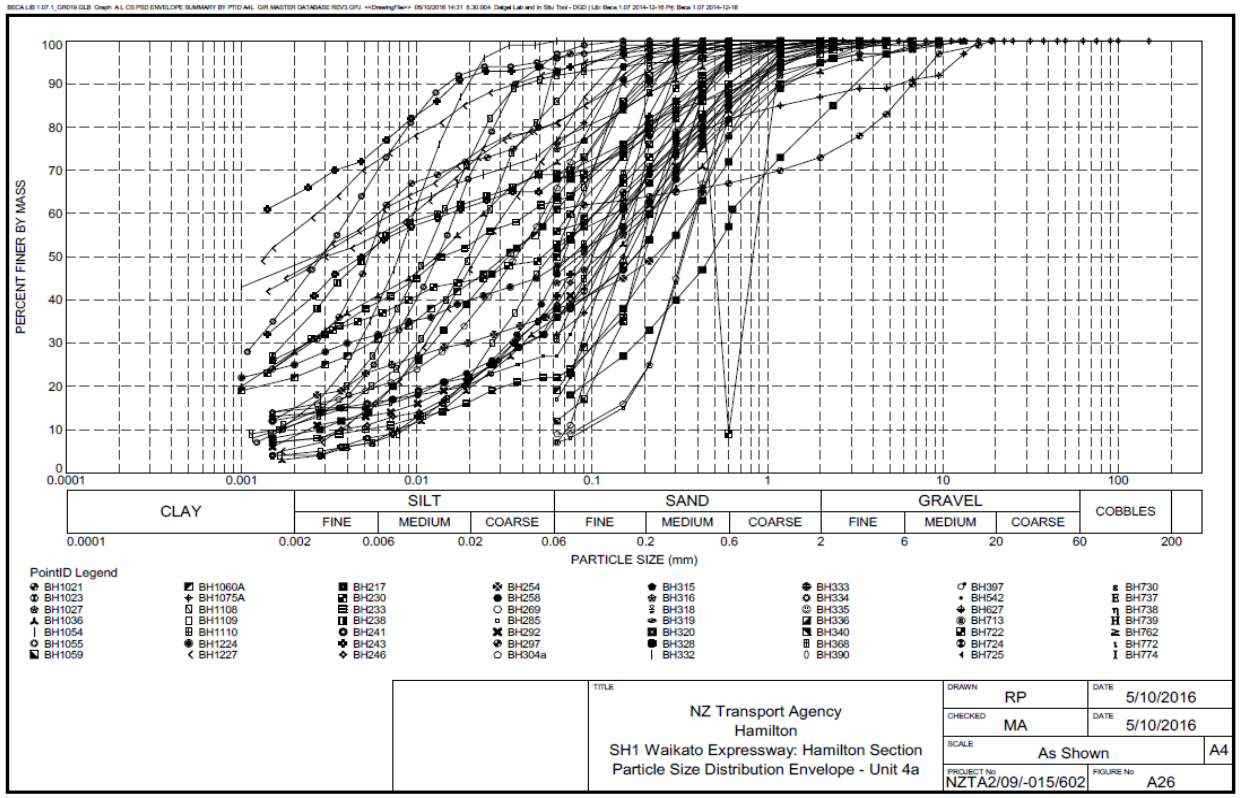
Sieve size (mm)	19.0	2.36	0.60	0.30	0.15	0.075
Weight passing %	100	100-50	90-20	60-10	25-0	10-0

CASE STUDY

Design review:

1. Check Compatibility of Bedding and Embankment Materials:





Migration of fines

	Culverts	Bedding	Culvert Chainage (approx)	Insitu Gound Conditions	D_{15} mm	d_{85} mm	D_{15}/d_{85}
1	**B**	GAP30	550	Unit 2A (Hineura Silts/Sands)	1.5	0.6	2.5
2	**C**	GAP30	750	Unit 2A (Hinuera Silts/Sands)	1.5	0.6	2.5
3	**C1**	GAP65	1050	Unit 2A (Hinuera Silts/Sands) - Some peat/recent alluvials	3	0.6	5
4	**D**	GAP30	1700	Unit 2A (Hinuera Silts/Sands) - Some peat/recent alluvials	1.5	0.6	2.5
5	**E**	GAP65	1900	Unit 2A (Hinuera Silts/Sands)	3	0.6	5
6	**F**	GAP65	2450	Unit 2A (Hinuera Silts/Sands)	3	0.6	5
7	**G**	GAP65	2800	Unit 2A (Hineura Silts/Sands)	3	0.6	5
8	**H**	GAP65	3600	Unit 2A (Hinuera Silts/Sands)	3	0.6	5
9	**K**	GAP65	4500	Unit 4A (Hamilton Ash)	3	0.2	15
10	**AF**	GAP65	14350	Unit 2A (Hineura Silts/Sands)	3	0.6	5
11	**Ryburn 1**	GAP65	240	Unit 2A (Hinuera Silts/Sands)	3	0.6	5
12	**Ryburn 2**	GAP65	445	Unit 2A (Hinuera Silts/Sands)	3	0.6	5

Design review:

2. Check Compaction and applicability of Reduced Bedding Factor:

No.	Culverts	Bedding Material	Culvert Chainage (approx)	Pipe Diameter ND *mm*	Pipe Class	Standard Test Proof Load *kN/m*	Average Field Compaction *%*	Posative Projection Embankment Load on Pipe *kN/m*					Negative Projection Embankment Load on Pipe *kN/m*	
								HS3 - BF = 4.0	HS3 (Reduced) - BF = 3.4	HS2 - BF = 2.5	HS1 - BF = 2.0	H1 - BF = 1.5	HS3 (Reduced) - BF = 3.4	HS2 - BF = 2.5
1	**B**	GAP30	550	1650	4	116	98.88	N/A	**43.9**	**53.2**	**62**	**76.7**	N/A	N/A
2	**C**	GAP30, GAP65	750	1050	2	42	102.1	N/A	**28.5**	**34.9**	**41**	N/A	N/A	N/A
3	**C1**	GAP65	1050	**1500**	**3**	**81**	**99.7**	N/A	**47.8**	**62**	**75.4**	N/A	N/A	N/A
4	**D**	GAP30	1700	1050	2	42	96.8	N/A	**30.2**	**37.7**	N/A	N/A	N/A	N/A
5	**E**	GAP65	1900	1200	2	46	100	N/A	**35.8**	**46**	N/A	N/A	N/A	N/A
6	**F**	GAP65	2450	**1050**	**2**	**42**	96.4	N/A	**37**	N/A	N/A	N/A	N/A	39.9
7	**G**	GAP65	2800	**1500**	**4**	**108**	**96.8**	N/A	**61.7**	**81.4**	**100**	N/A	N/A	N/A
8	**H**	GAP65	3600	**1200**	**4**	**92**	96.8	N/A	**45.5**	**59.5**	**72.4**	N/A	N/A	N/A
9	**K**	GAP65	4500	**900**	**4**	**74**	96.5	N/A	**54.3**	**72.7**	N/A	N/A	N/A	66.9
10	**AF**	GAP65	14350	**1050**	**4**	**84**	**97.9**	**84**	**126**	N/A	N/A	N/A	**68.7**	**92.7**
11	**Ryburn 1**	GAP65	240	**525**	**2**	**23**	**93.3**	N/A	N/A	N/A	N/A	**17.5**	N/A	N/A
12	**Ryburn 2**	GAP65	445	**525**	**2**	**23**	**99.3**	N/A	N/A	N/A	N/A	**17.5**	N/A	N/A

CASE STUDY

Design review recommendations were:

- **Accept installation as complying with the intent of AS/NZS 3725:2007 and CPAA Guidelines.**
- **Change the condition of culverts A and AF to “Negative Projection” by creating “Induced Trench Condition” – Digg a trench on top of the pipe and lay a layer of compressible materials, then back fill with loose fill.**
- **Install Concrete Seep collars to stop flow of water around pipes of culvert K where the soil and bedding materials are not compatible.**

CONCLUSIONS

From the above discussion and review it is possible to draw the following conclusions:

- **AS/NZS 3725:2007 specifies bedding material with grading limits that satisfy all requirements of installation by achieving good compaction and support to the installed pipes.**
- **The Standard bedding material grading have been selected to mitigate the risk of migration of fines from surrounding soils and maintain stability in both wet and dry conditions.**
- **The Standard bedding maximum size of aggregates is designed to suit all sizes of concrete pipes.**

CONCLUSIONS

- **The Standard allow Designers and Installers to use materials other than that specified.**
- **Designers may use standard soil mechanics checks for the risk of migration of fines.**
- **Designers may use a reduced bedding factors values with level of reduction based on Engineering Judgment.**

ACKNOWLEDGEMENTS

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Questions