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REVISED BEDDING FACTORS FOR VITRIFIED CLAY DRAINS AND SEWERS

This Information and Guidance Note contains advice relating to revised bedding factors for vitrified clay drains and sewers.

It is the intention to pursue the principle of common bedding factors for all rigid pipes and it is envisaged that work in progress will enable advice to be given for other rigid pipe materials in pursuance of this aim. This *interim* Guidance Note therefore contains advice which will be incorporated into guidance relating to bedding factors for all rigid pipes at an appropriate time.

1. INTRODUCTION

Over the past thirteen years an extensive programme of research has been carried out by the Clay Pipe Development Association into the structural design of vitrified clay pipelines. The research has led to a greater understanding of the loads on buried clay pipelines and to a revision of the established values of bedding factors.

The Bedding Factors under consideration in this Note are for Class F, B and S beddings, Figures 1, 2 and 3, which use granular material.

2. BEDDING FACTORS

The load required to produce failure of a pipe in the ground is higher than the load required to produce failure in a crushing test machine. The ratio of the failure load for the pipe installed in the ground to the failure load in the crushing test machine is known as the Bedding Factor.[1]

The Bedding Factor varies with the support angle of granular material under the pipe. The current values of Bedding Factors for Class F, B and S beddings are 1.5, 1.9 and 2.2 respectively.

3. EXPERIMENTAL WORK

240 separate physical tests have been carried out in order to evaluate Bedding Factors. At the laboratories of the British Ceramic Research Limited and the Water Research Centre (WRc) loading tests were carried out on pipelines in trenches and the strains in pipes together with the earth pressures above pipes were measured.

This experimental work was carried out on various pipe sizes and bedding conditions. The specifications adopted in the experimental work represented both normal and lower levels of site workmanship.[2] The normal level of workmanship was directly related to the Civil Engineering Specification for the Water Industry (CESWI). For the lower level of workmanship specification, all relevant aspects of CESWI were reviewed by WRc and realistic relaxations of tolerances were made. The specification for this lower level of workmanship was considered to be that beyond which no rational design procedures could be based.

The effect of workmanship on Bedding Factors was clearly demonstrated with values obtained at the lower level of workmanship significantly less than those obtained under the normal levels of workmanship. The Bedding Factor values recommended in this Note have been based on the mean results obtained from this lower level of workmanship specification.

The experimental work also showed that Bedding Factors are not influenced by the nominal pipe size.

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4. NUMERICAL MODEL

A calibrated numerical model was developed[3] for a buried 800mm diameter buried vitrified clay pipe under load and installed to a lower level of workmanship in the WRc test pit. This model was based on the finite element method of stress analysis and showed a close correlation with the physical test measurements. The model was used to assess the previous physical tests carried out. The finite element analyses also showed agreement with the Marston Wide Trench Theory for loads on buried pipelines.

5. REVISED BEDDING FACTORS

On the basis of the experimental and numerical modelling work carried out, Bedding Factors for class F, B and S beddings were calculated to be greater than 1.9, 2.5 and 2.5 respectively.

6. DESIGN RECOMMENDATIONS

1) Bedding factors of 1.9, 2.5 and 2.5 may be used with vitrified clay pipes for class F, B and S beddings respectively.

2) Existing design methods do not need to be changed. Design loads should be determined by use of Marston Wide Trench Theory. Designers are reminded that, when manufacturers tables are used to calculate loads on pipelines, they must:

   (a) establish whether wide or narrow trench theory has been used in the preparation of the tables, and

   (b) in general use wide trench theory. For larger pipelines there may be economies in using narrow trench theory. However, wide trench theory should be adopted if there is the slightest doubt that specified trench widths, based on narrow trench theory, may not be achieved on site.

3) Where pipeline construction is supervised and the requirements of CESWI can reasonably be expected to be achieved, the normally accepted design factor of safety of 1.25 can be used. The pipeline's location, its relative importance and the quality and regularity of supervision may also influence the factor of safety chosen and under certain circumstances a higher factor of safety may be appropriate. Information on the reliability of recently constructed sewers is currently being reviewed and comprehensive guidance on factors of safety will be given in a later guidance note.

7. REFERENCES

1. Buried Rigid Pipes. O.C. Young and J.J. Trott, Elsevier Applied Science Publishers.

2. WRc Report C33 for Clay Pipe Development Association. Physical Testing of DN 800 Clayware Pipes Contract 2.

3. The development of a mathematical model for buried clay pipes. K.J. Sheppard, C.E.G. Bland, DJ. Naylor. The Public Health Engineer. Vol. 12 No. 4 - October 1984.

Table 1 - Size of granular material

Nominal bore of pipe (mm)	**Size (mm)**	
	single-sized	**graded**
100-125	10	-
150-200	**10 or** 14	14 to 5
225-300	**10,** 14 **or** 20	14 to 5 or 20 to 5
375-500	14 or 20	14 to 5 or 20 to 5
exceeding 500	14, 20 or 40	14 to 5 20 to 5 or 40 to 5

All granular material to be single sized or graded in accordance with Table 1. Aggregates to BS 882, sintered pulverized-fuel ash to BS 3797 and air-cooled blast furnace slags to BS 1047 are suitable.

All selected backfill shall be in accordance with the Civil Engineering Specification to the Water Industry, Clause 2.46.3.

Dimension a = For sleeve jointed pipes, a minimum of 50mm or $1/6B_c$, whichever is the greater. For socketed pipes a minimum of 100mm or $1/6B_c$, whichever is the greater under barrels and not less than 50mm under sockets.

In rock or material containing hard spots:

a = For sleeve jointed pipes, a minimum of 150mm or $1/4B_c$, whichever is the greater. For socketed pipes, a minimum of 200mm or $1/4B_c$, whichever is the greater, under barrels and not less than 150mm under sockets.

B_c = outside pipe diameter.

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Figure 1
Class F
Bedding Factor 1.9

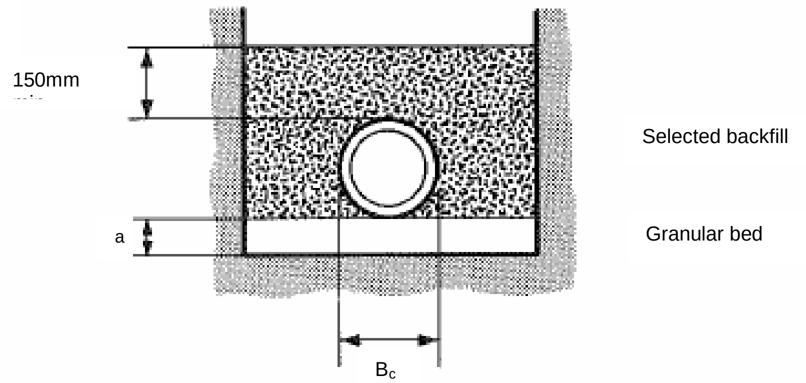

Figure 2
Class B
Bedding Factor 2.5

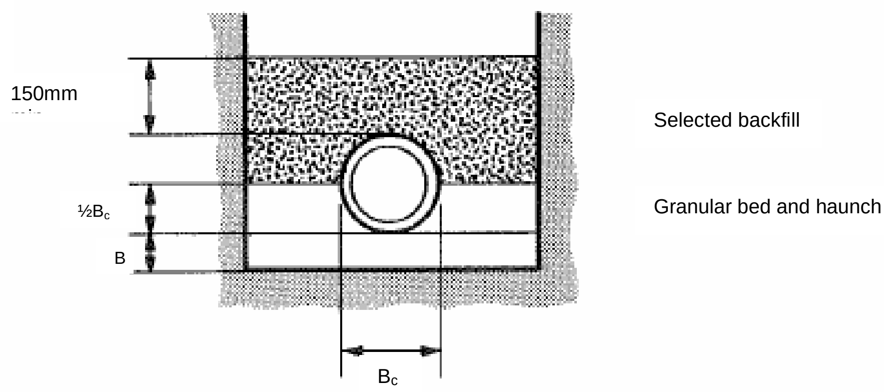

Figure 3
Class S
Bedding Factor 2.5