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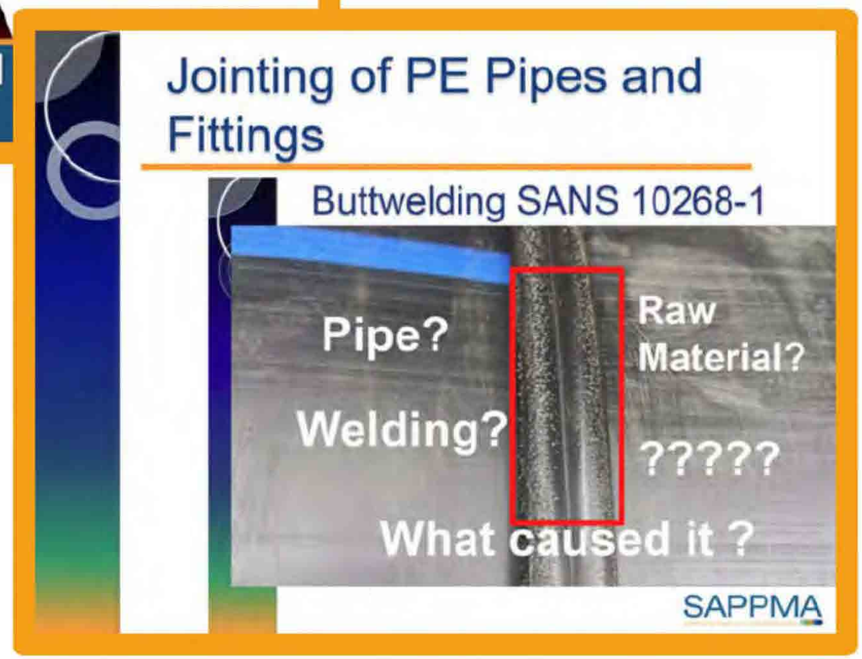
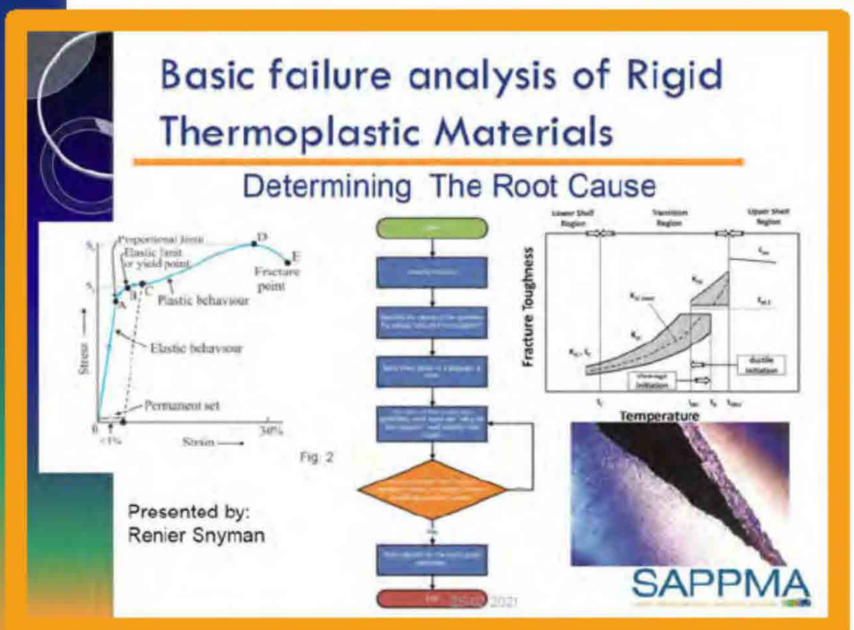
20-04-2021

WEBINAR III

April 2021

SAPPMA Webinar I & II on SAPPMA Web site





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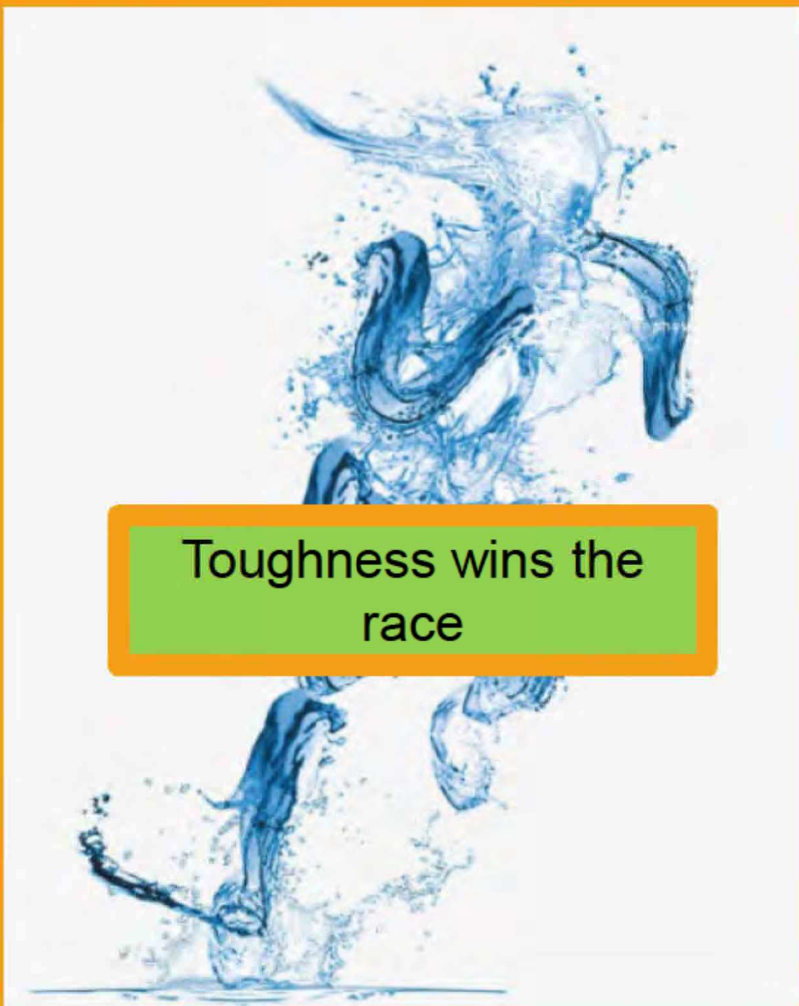
Thank you for your feedback and suggestions

20-04-2021

Strength and durability in our Flexibility

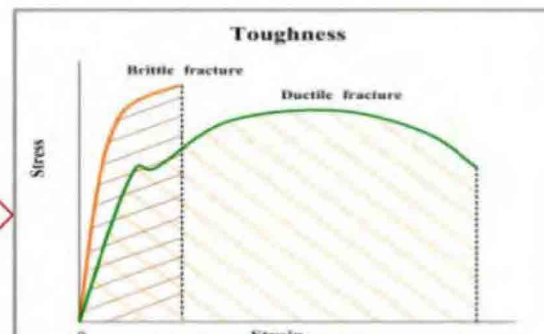


Toughness wins the race

Ductile of Material

toughness is the ability of a material to absorb energy and plastically deform without fracturing. One definition of material toughness is the amount of energy per unit volume that a material can absorb before rupturing.

- fail suddenly by cracking or spintering
- Much weaker in tension than in compressio
- no significant plastic deformation before fracture



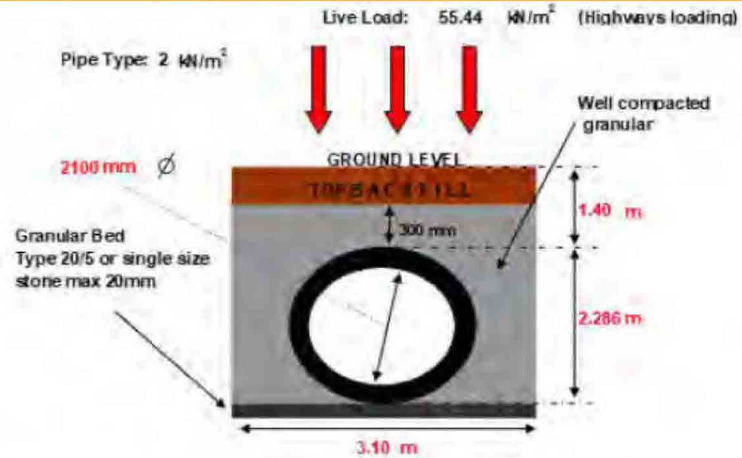
Toughness of Soft and Brittle Materials

- able to deform significantl y in to the inelastic range
- sustains significant plastic deformation prior to fracture

calculate the toughness

$$Toughness = \frac{\sigma \varepsilon}{2} = \frac{\sigma^2}{2E} \quad 8.13$$

How can it work ?



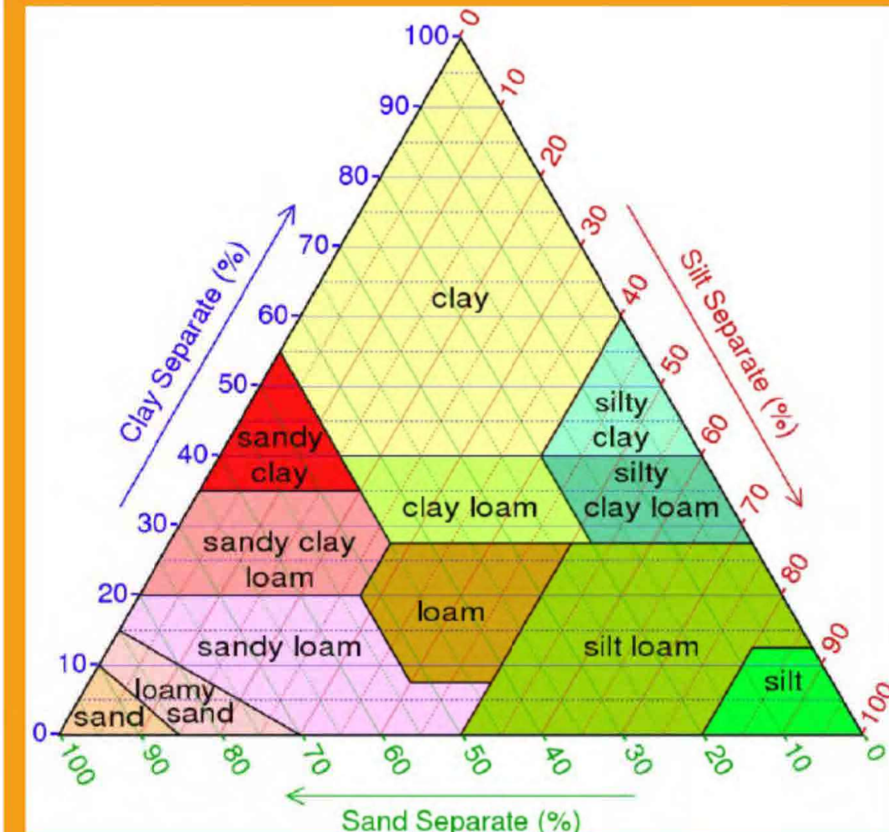
Calculations according to BS EN 1295 - 1 : 1998

Pipe Zone - From Table NA.6 [E'₂]: 20000 kN/m²
Guide Values of Modulus for Native Soil [E' 3]: 5000 kN/m²
Soil Type as in Table NA.1
Overall Soil Modulus [E']: 5917 kN/m² (Equation 16)
C_L: 0.295866 (Equation 17)
Initial Deflection: 1.81% (Equation 23)
Long Term Deflection: 1.87% Note: Initial Deflection using D_L set at 1.0 < 6% O.K

Total vertical external pressure: 82.038 kN/m² (Equation 15)
Long term critical pressure: 160.744 kN/m²
Short term critical pressure: 253.989 kN/m²

F.O.S against buckling: 2.606 (Equation 21) > 2 O.K

Deflection Test: PASSED
Buckling Test: PASSED



Let us bring it all together

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Presenter

SAPPMA Webinar III

20 April 2021

Ian Venter

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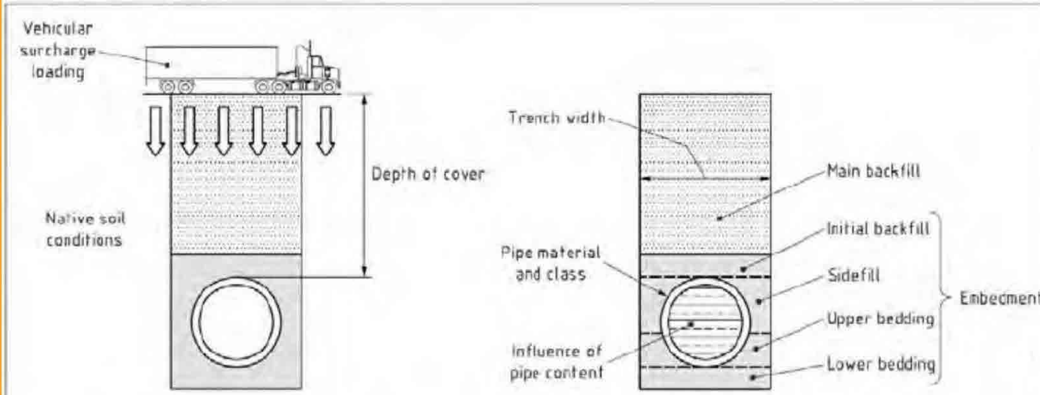
Design of Buried Thermoplastics Pipes

Results of a European research project by APME & TEPPFA

4.1 General

The purpose of the structural design of the cross-section of buried pipelines is to ensure that they are designed so that the optimum materials and embedments are selected for the given installation, whilst meeting all the necessary design criteria. For design considerations see Figure 1.

Figure 1 **Design considerations**



a) Factors to be considered in the design environment

b) Factors to be considered – Designer controlled parameters

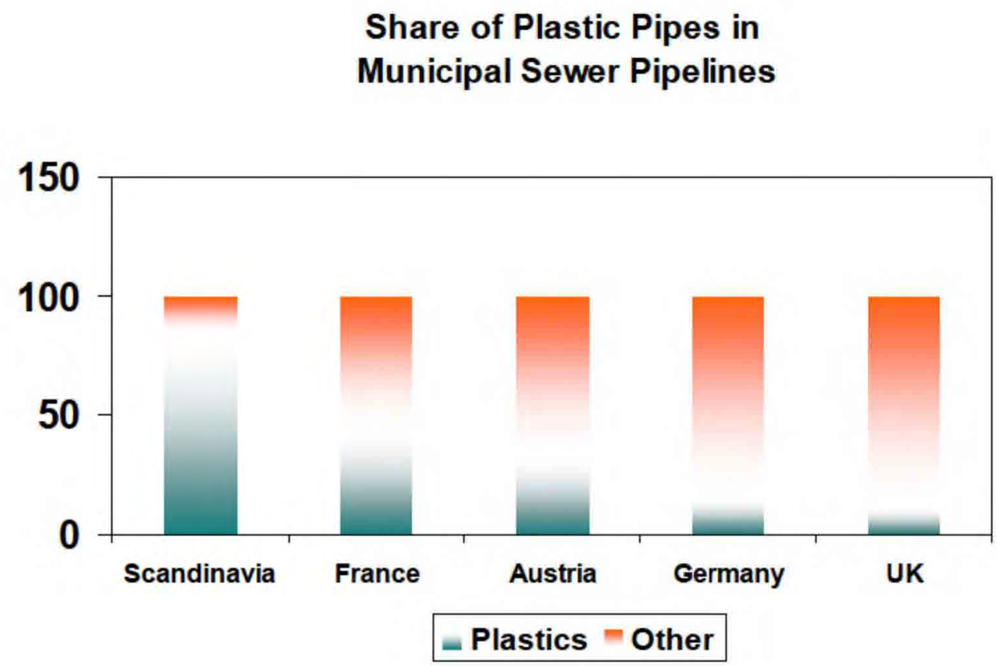
NOTE Definition of sidefill in BS EN 1295-1:1997 includes sidefill and upper bedding as shown in Figure 1.

Organisations supporting the project

- TEPPFA
  The European Plastics Pipe and Fitting Association
- APME
  Association of Plastics Manufacturers in Europe

Current situation

- Rigid materials still dominate on many European markets.
- Prevailing design practices often tailored for rigid pipes.
- Flexibility considered as a weakness.
- Designers not always familiar with the behavior of plastic pipes when buried underground.



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Misconceptions about plastics pipes

Deflection increases with installation depth and with traffic load.

Pipe ring stiffness is the governing factor determining the performance.

Pipe looses stiffness with time, the load bearing capacity reduces.

To predict the structural performance an extensive design method is needed.

Flexible behaviour is a disadvantage.

Deflected pipe looses its discharge capacity and tightness.

TEPPFA and APME started an extensive research project to address these arguments.

Objectives of the project

- Show the relative importance of the parameters.
- Prove flexibility to be a strength instead of a disadvantage.
- Develop a design approach in balance with achievable installation quality and actual behaviour.
- Contribute to the development of the European standards with real field trials / test results.
- Provide material to communicate the project results to the marketplace.

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Steering Committee

Name	Company / Association		
Ingemar Björklund	KWH Pipe / NPG	(S)	Chairman
Helmut Leitner	Solvay / APME	(B)	
Tiem Meijering	Polva-Pipelife / FKS (NL)		
Michael Giay	REHAU / ON	(A)	
Dieter Scharwächter	Uponor / KRV	(D)	
Jacques Nury	Alphacan / STRPE-PVC	(F)	
Constantino Gonzalez	ITEPE / ASETUB	(E)	
Alan Headford	Durapipe-S&LP / BPF	(UK)	
Jukka Kallioinen	Uponor	(D)	
Loek Wubbolt	Omniplast	(NL)	
Trefor Jones	Wavin	(UK)	
Frans Alferink	Wavin M&T	(NL)	Secretary

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Project Group

• Frans Alferink (NL)	Wavin M&T	Project manager
• Lars-Eric Janson	SWECO	Supervisor (S)
• Jonathan Olliff	Montgomery / Watson	Supervisor (UK)

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Project set-up

Started in July 1996, Costs : Euro 450.000,=

- Full scale field trials with different materials, stiffnesses, soils and installation conditions carried out in Haarle and Wons (NL), involving:
  - Traffic load simulations
  - Depth variations
  - Internal pressure
  - Time effect

- Supporting laboratory tests.
- Design exercises together with leading European experts to compare existing calculation methods with results from field measurements.
- Evaluation with European design experts in a workshop.

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European experts involved

Expert	Design Method	Country
	EN 1295	
Günther Leonhardt	ATV A 127	(Germany)
Marcel Gerbault	Fascicule 70	(France)
Walther Netzer	ÖNORM B 5012	(Austria)
Lars-Eric Janson	VAV P70	(Sweden)
Jonathan Olliff	PSSM	(United Kingdom)
	Others	
Hubert Schneider	GRP-draft	(Germany)
Frans Alferink	CalVis	(The Netherlands)
Tiem Meijering	Bossen	(The Netherlands)

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Approach with European design experts

Step	Activity
1	Consultation with experts regarding field trials.
2	European experts calculating the pipe deflections by using the different methods.
3	Establishing test fields and carrying out extensive measurements.
4	Continuing the field measurements at defined times.
5	Evaluation of all results in a two day workshop (December 1997).

The field trials : Installed pipes

Material	Stiffness [kN/m²]	Cover [m]	Installed length [m]
Silty sand, November 1996			
PVC	2 and 4	1.15	120
		1.85	60
PE	5	1.15	45
Steel	4	1.85	20
Silty clay, August 1997			
PE	5	1.15	60
		3.0	60

Documented test data

- Soil
  - Grain size distribution
  - Grain shape
  - Proctor density
  - Menard test
  - Cone penetration test
  - Tri-axial test (clay)
  - Cone-pressiometer test
  - Impact cone test
  - Oedometer test

- Pipe
  - Dimensions
  - Stiffness
  - Creep ratio
  - Deflections
    - time dependency
    - under internal pressure
    - under traffic load
    - under ground water
  - Strain under deformation

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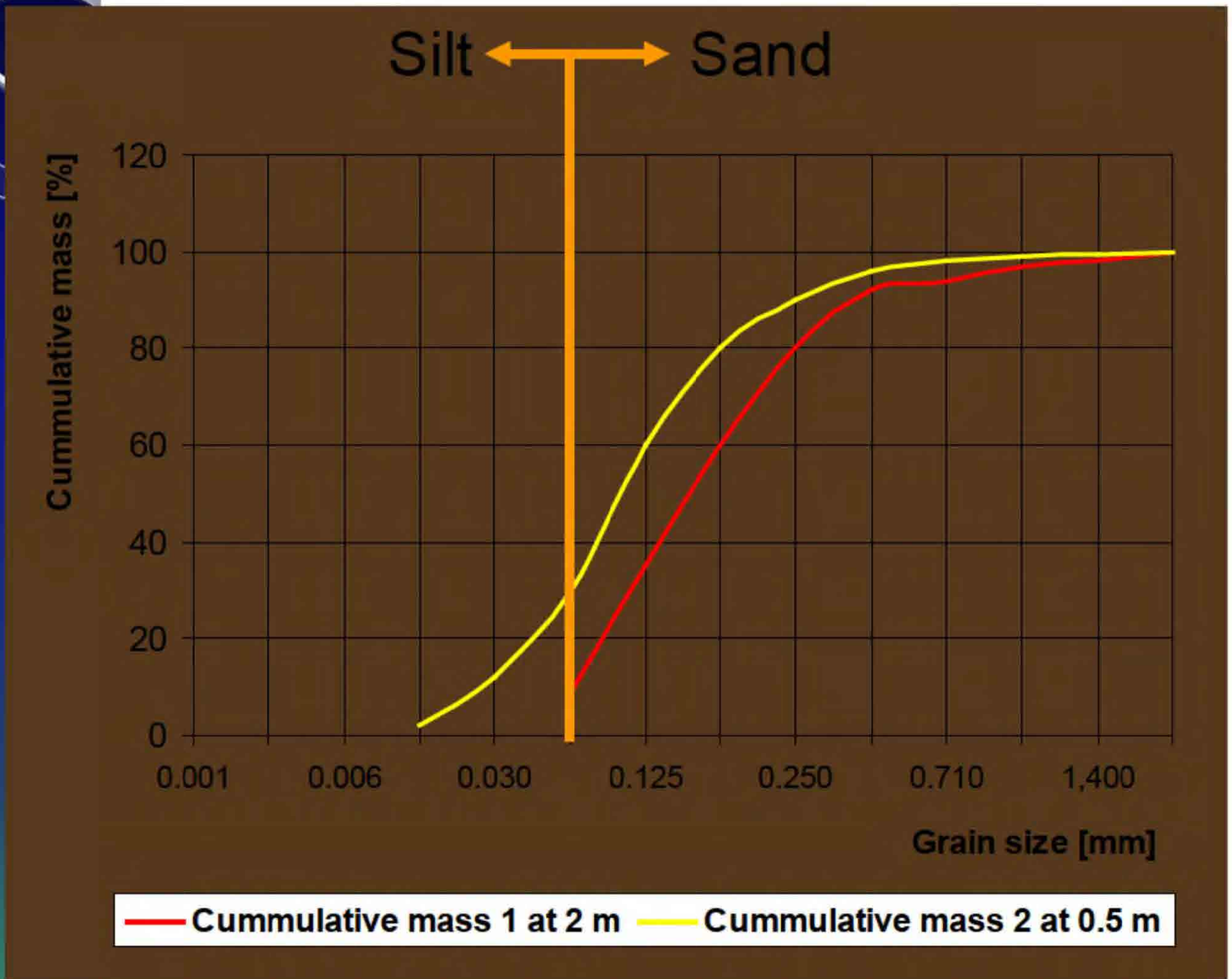
Natural variations in soil



Grain size distributions of sand taken at two different depths

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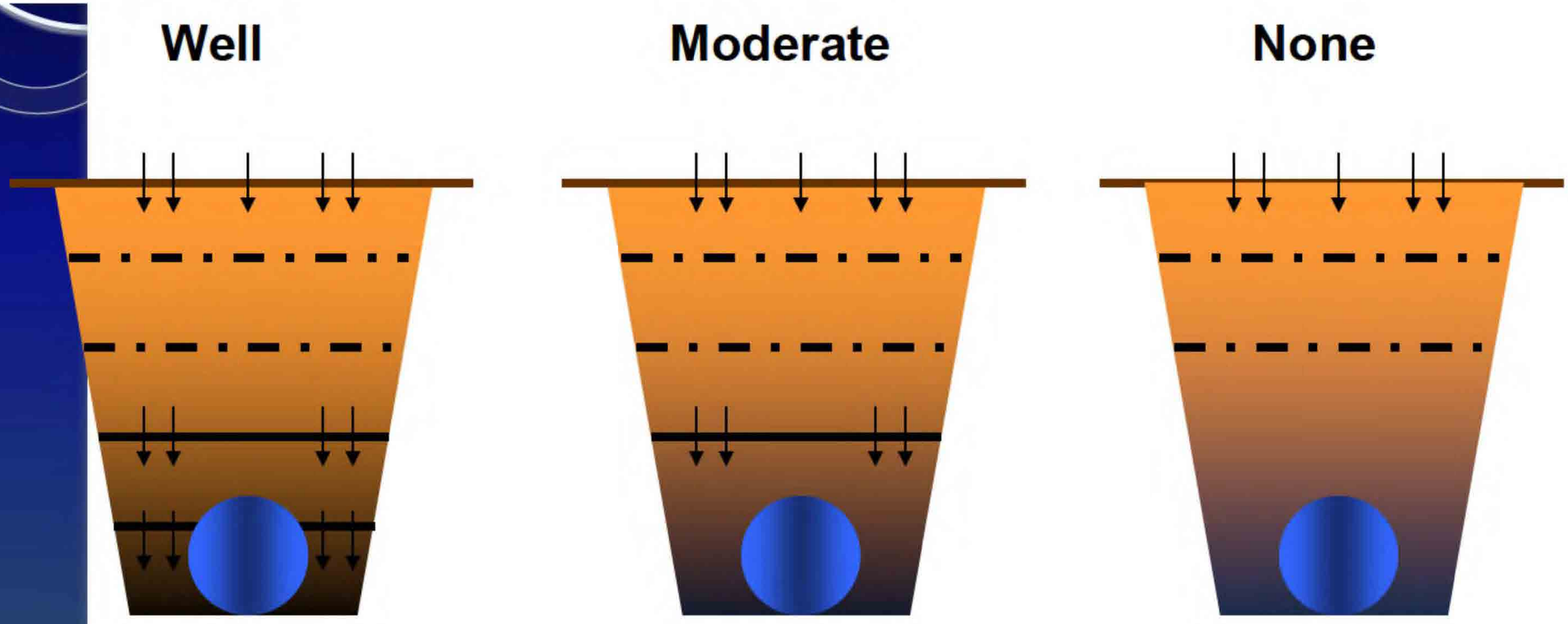
Installation practices used in the project



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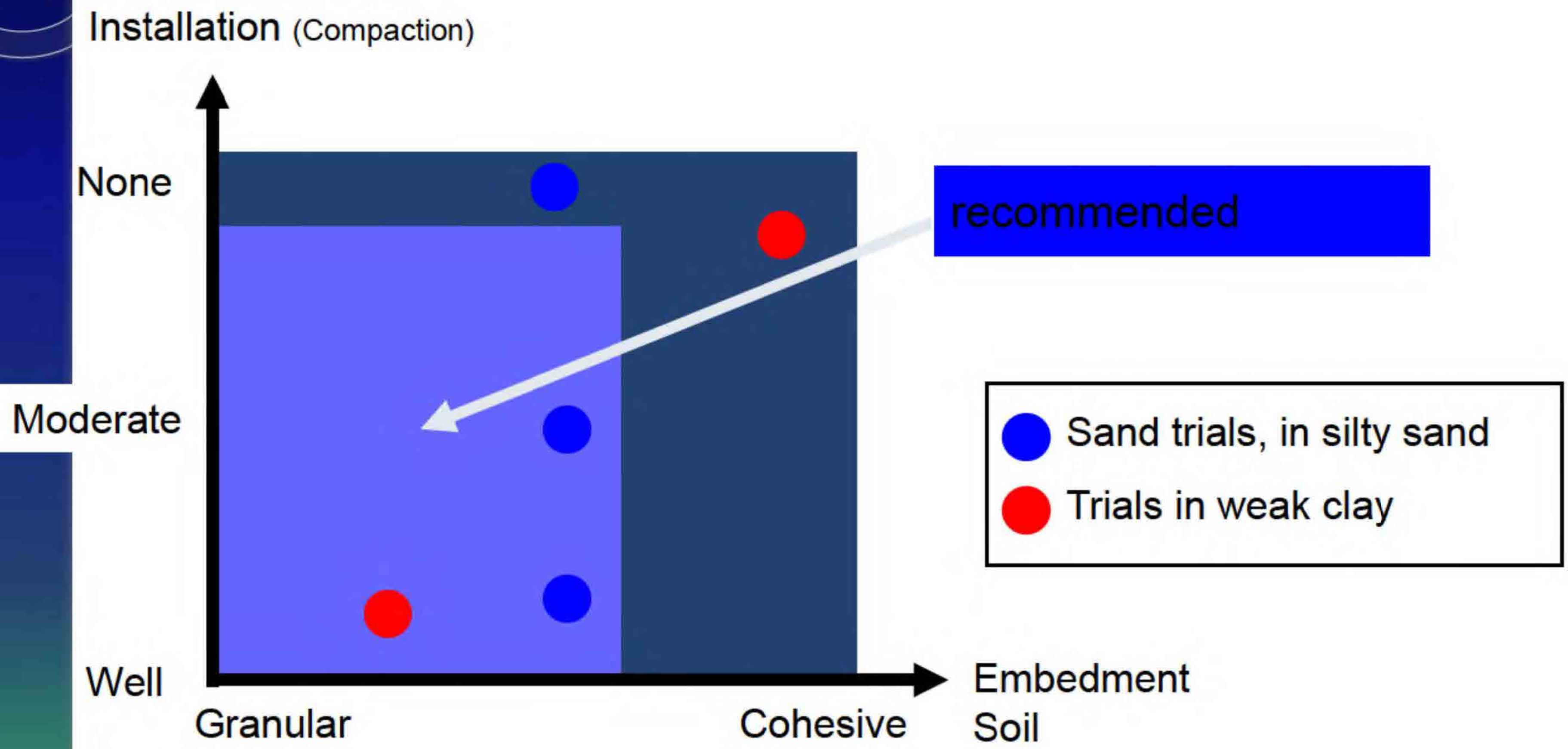
Position of trials

Position of trials in generalised application window



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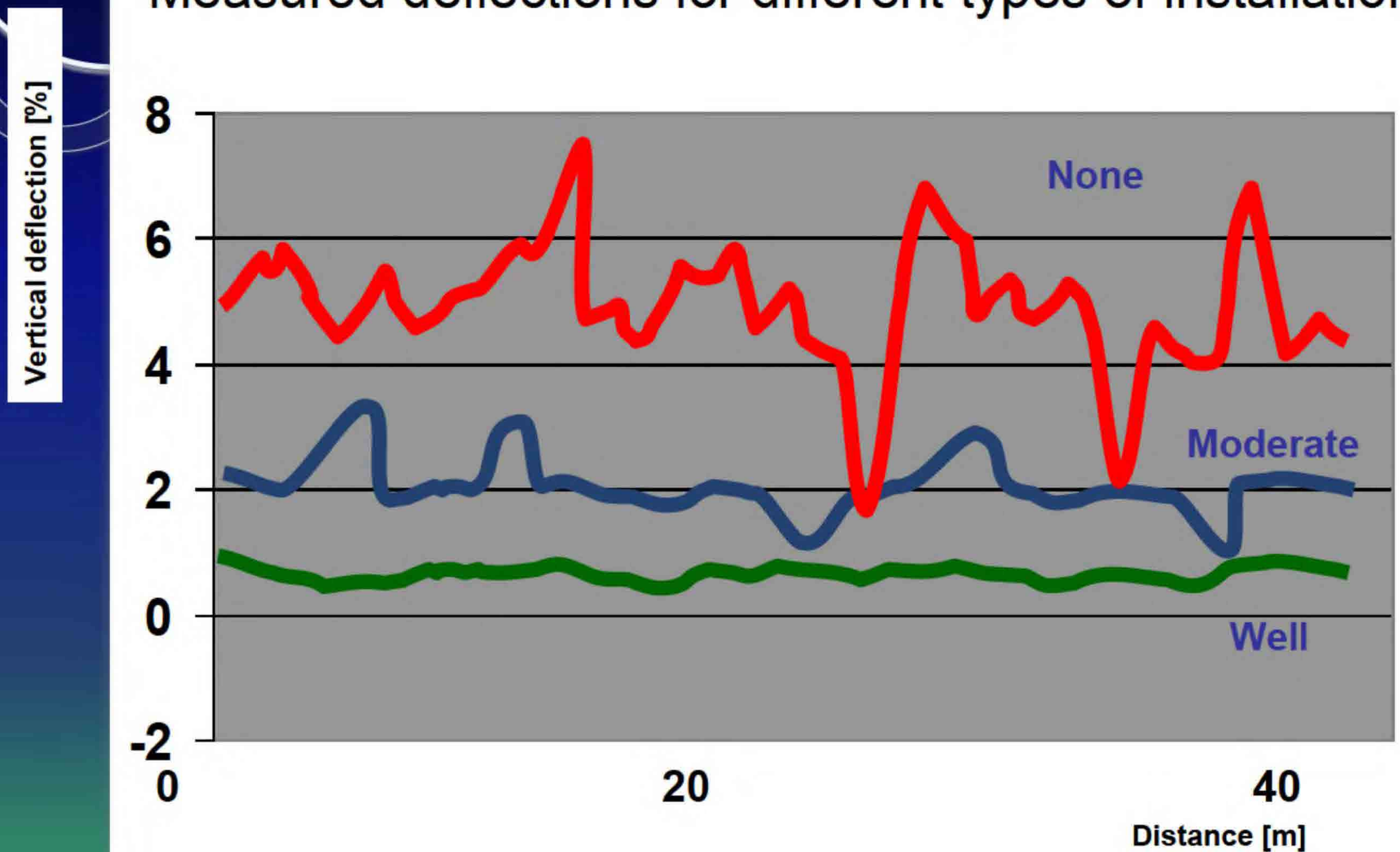
Pipe deflection

Measured deflections for different types of installation



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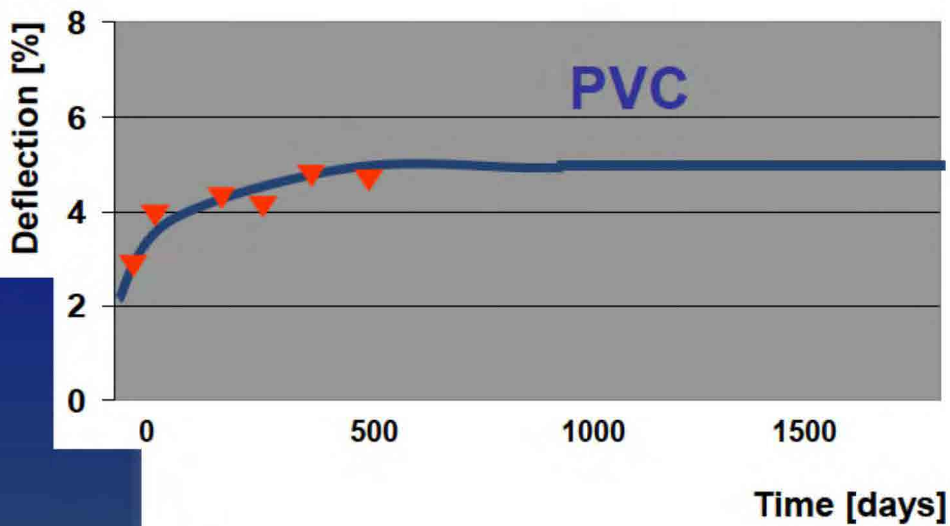
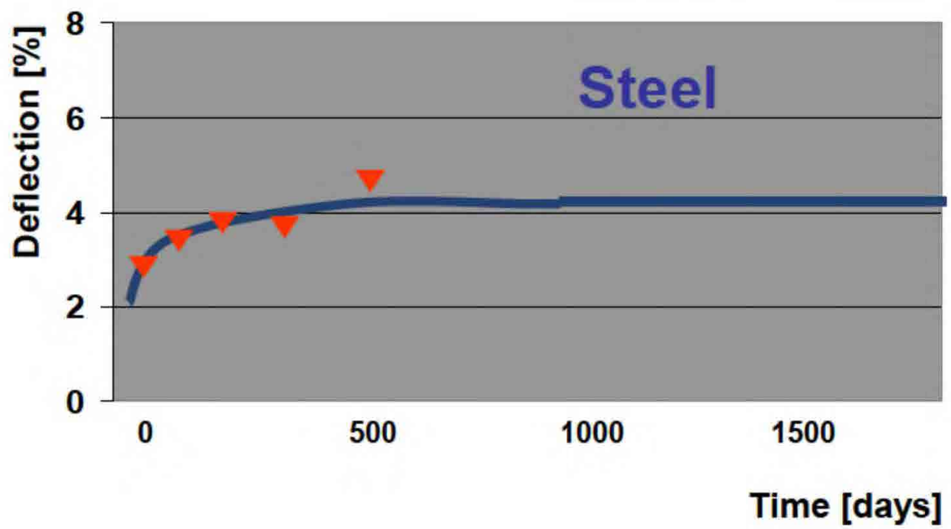
Findings from workshop discussions

- "Installation of pipeline systems varies from meter to meter depending on many aspects such as workmanship, native soil variations, weather conditions and logistics in the field."
- "Consequently, the installation variability results in variations in ring deflection along the pipeline for flexible pipes and in variations in bending moments along the pipeline for rigid and semi-rigid pipes."

No difference between PVC / Steel

Time dependency of the deflection





▼ Measured

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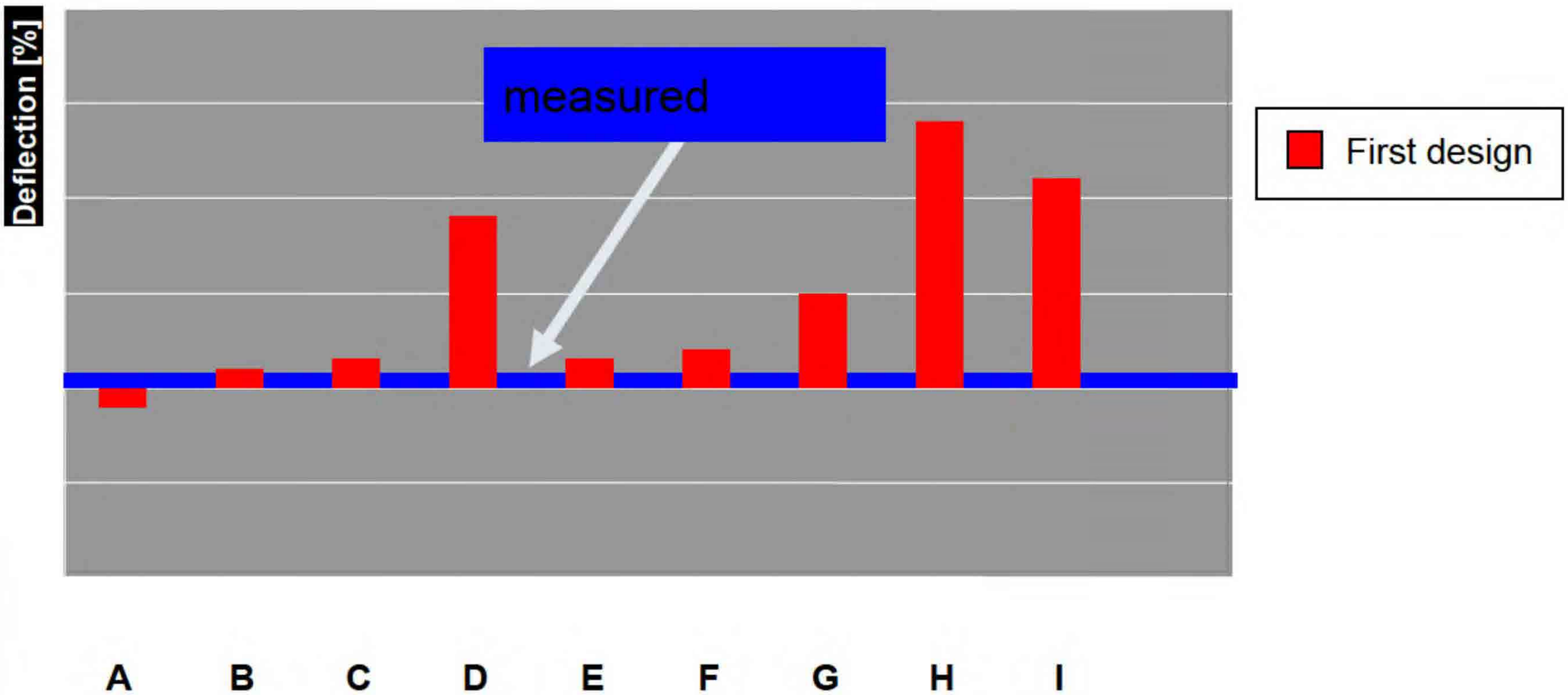
Calculated and measured deflections

Granular soil, good installation



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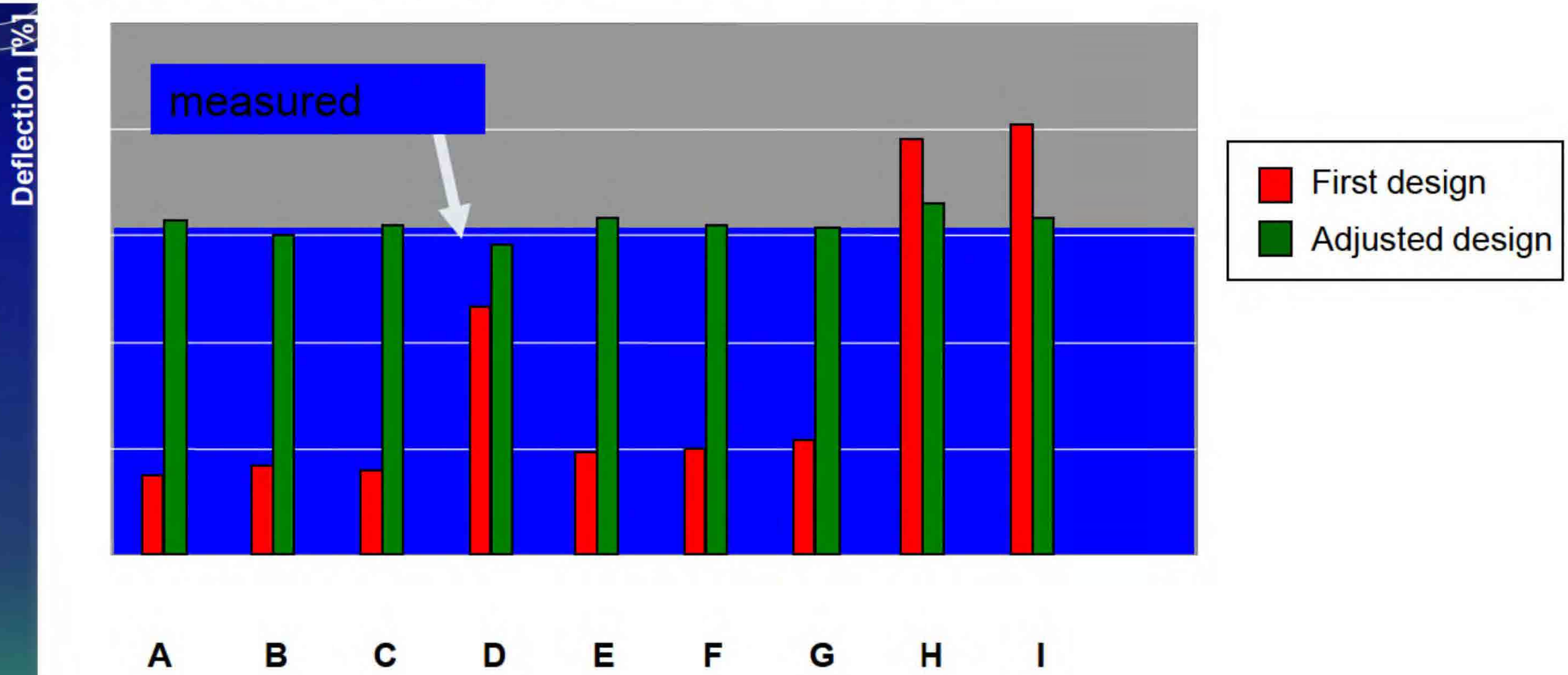
Calculated and measured deflections

Granular soil, poor installation



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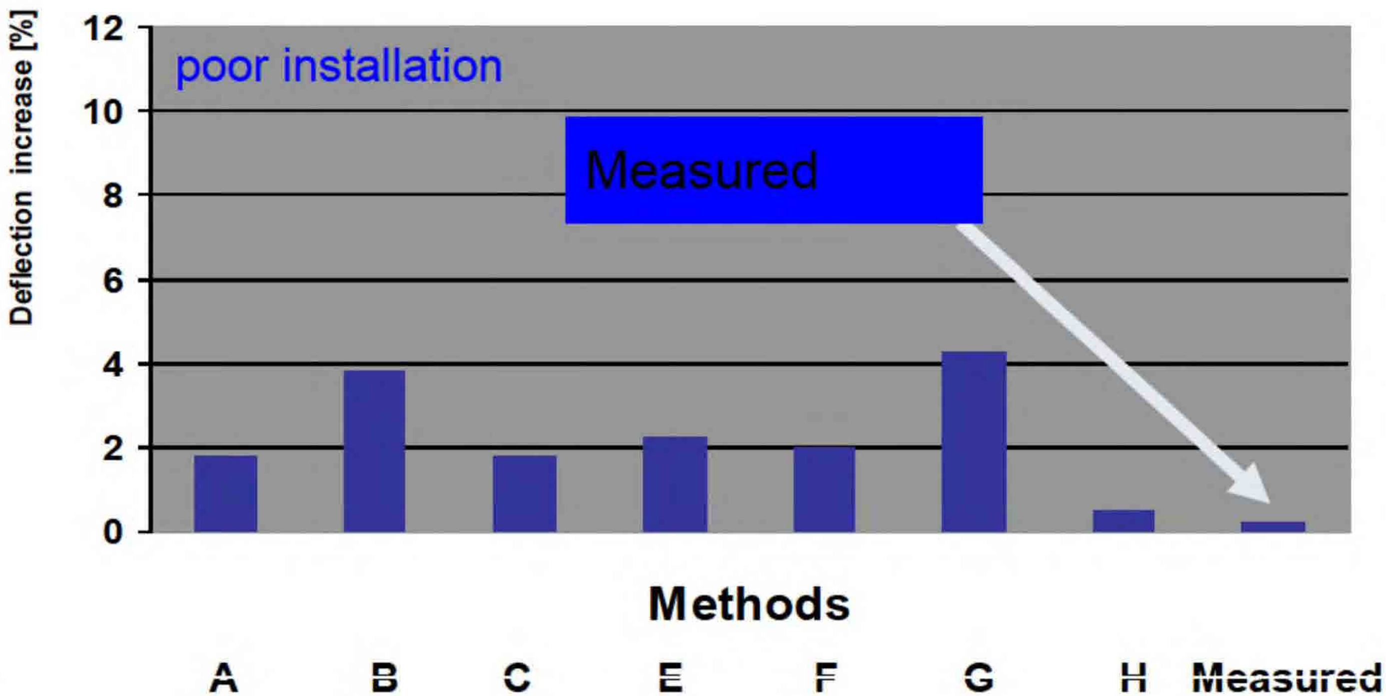
Calculated and measured deflections

Effect of traffic



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The paradox

"Sophisticated design methods rely on the quality of the input parameters and that the installation is strict according to the prescriptions.

In such cases a "Well" type of installation is obtained, resulting in very low deflections, and hence design is not important in such cases.

When the quality of the input values is less good, as when installations are becoming more difficult and hence limit state conditions are more likely to occur, sophisticated design methods are no longer appropriate".

Summary of the main results

- Good understanding of soil-pipe interaction.
- 20 well documented data sets on the different installations.
- Simplified approach with a new design-tool applicable to the majority of pipe installations.
- More confidence in plastics pipe performance even under poor installation conditions.

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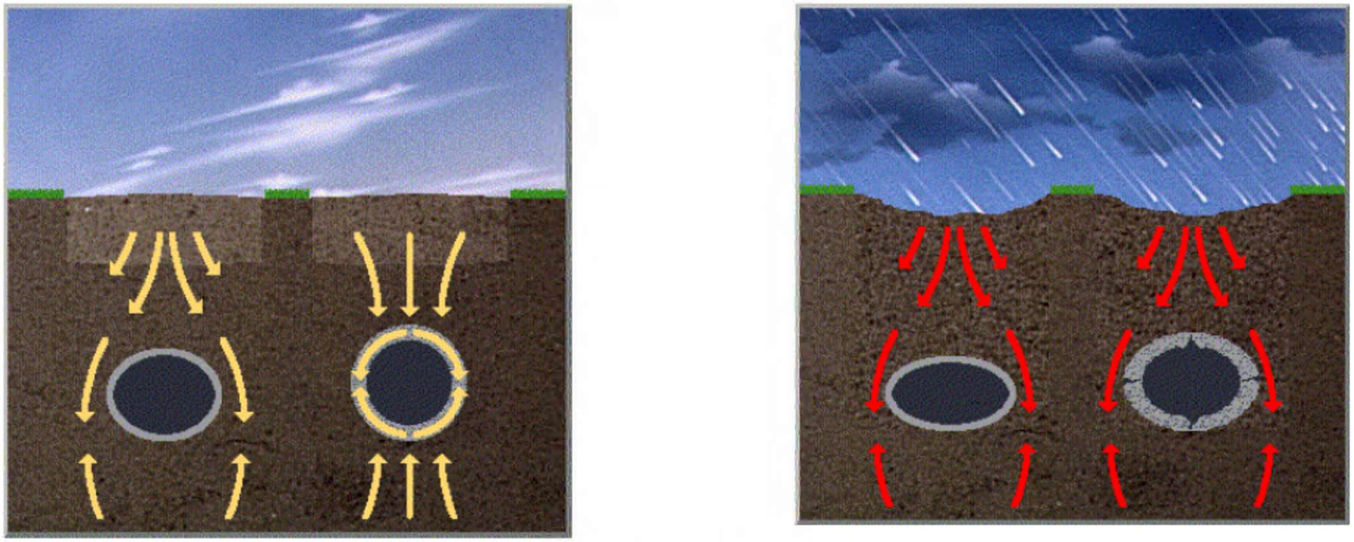
The pipe soil interaction

Ring deflection of flexible pipes is controlled by the settlement of the soil. After settlement, traffic and other loads do not affect pipe deflection.



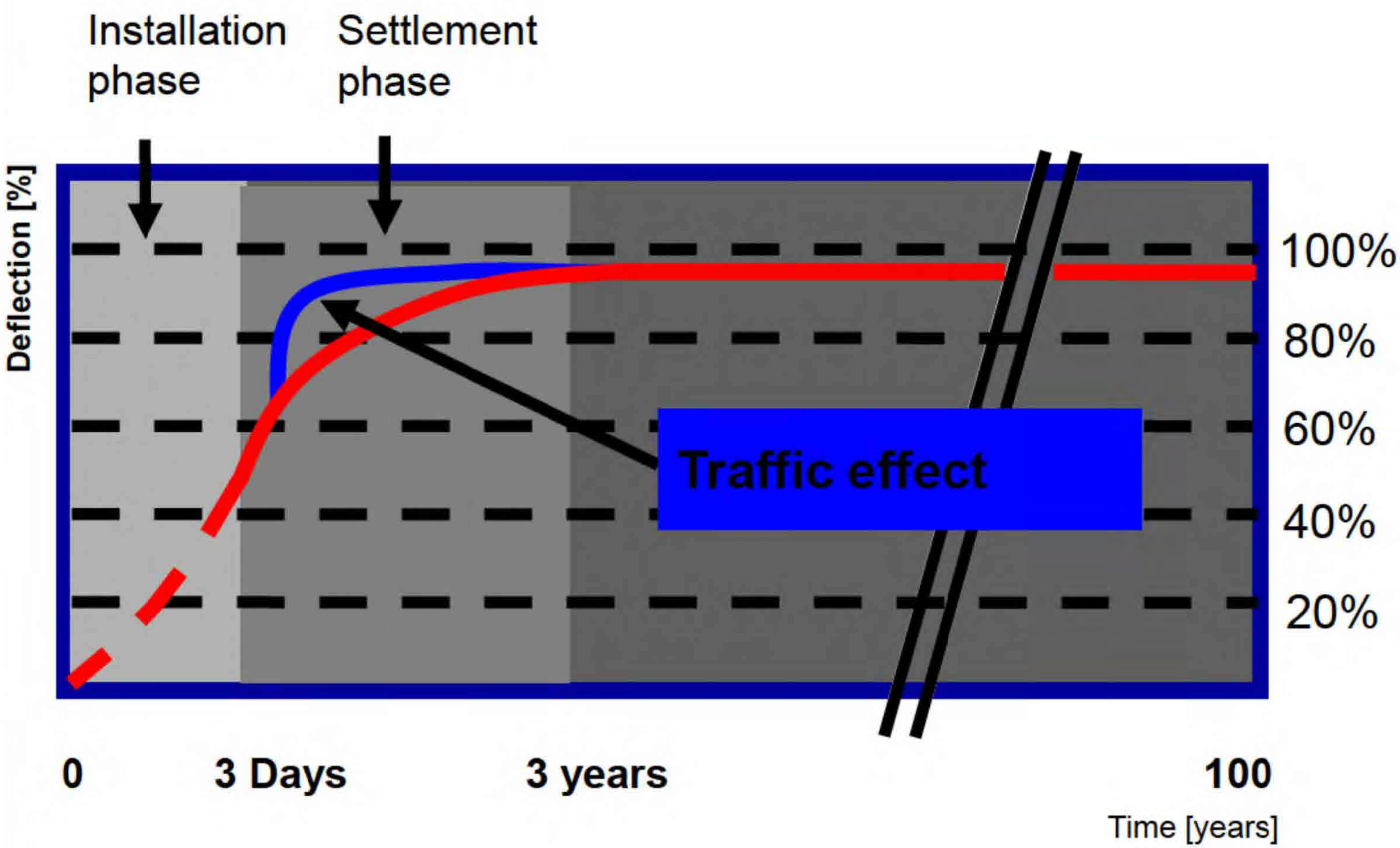
Deflection is safety!

When pipes are relatively more rigid than the soil, the traffic and other loads have to be resisted by the pipe.

Facts about deflection

- Depth of cover is not relevant.
- Traffic load has no significant effect.
- Deflection and its variation depends more on the installation quality than on the pipe stiffness.

Facts about deflection



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Facts about deflection

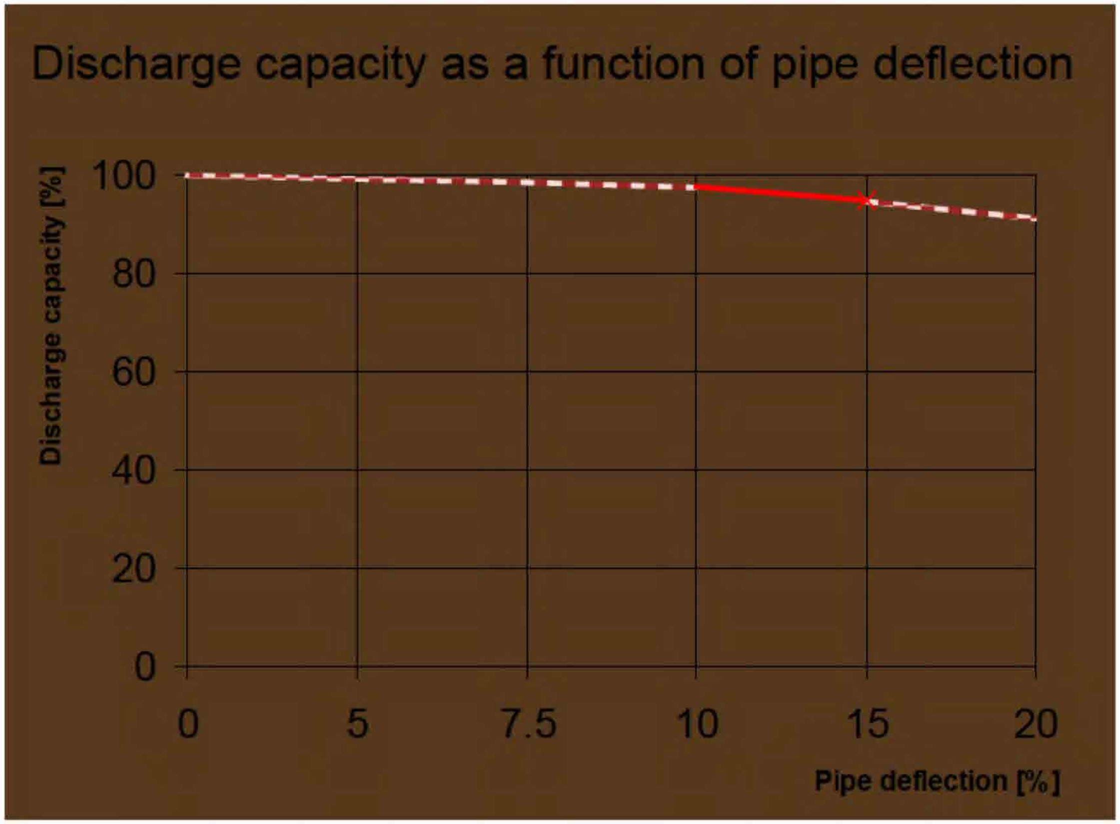
- Recommended max. values :

  8% initial, 12.5 % final.

  (ISO TR 7073)

- Pipes deflected up to 10 % - only 2.5 % reduction in discharge capacity.

Deflection is NO issue!



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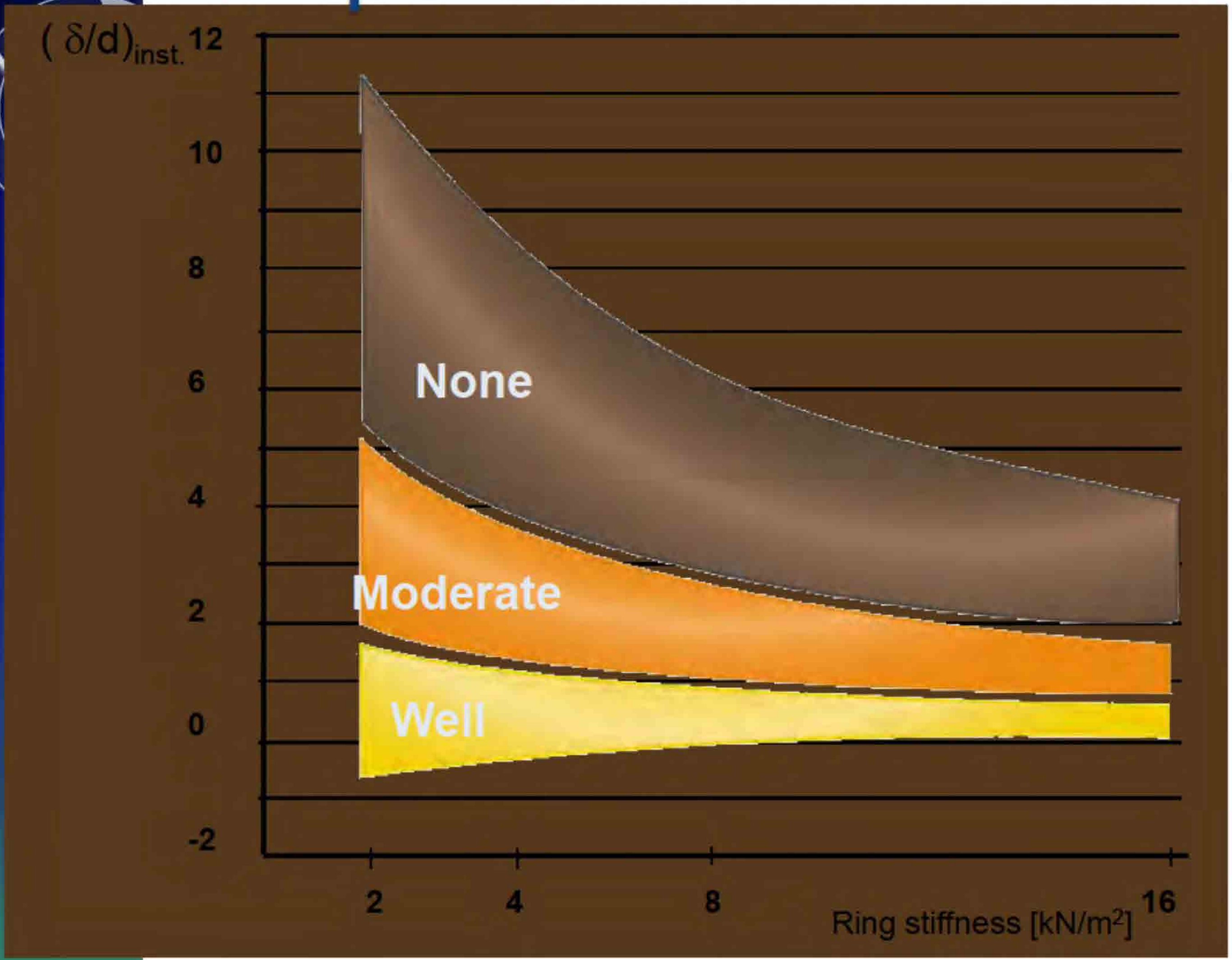
Pipe deflection after installation



The average deflections immediately after installation are represented by the lower boundary of each area, and the maximum values by the upper boundaries.

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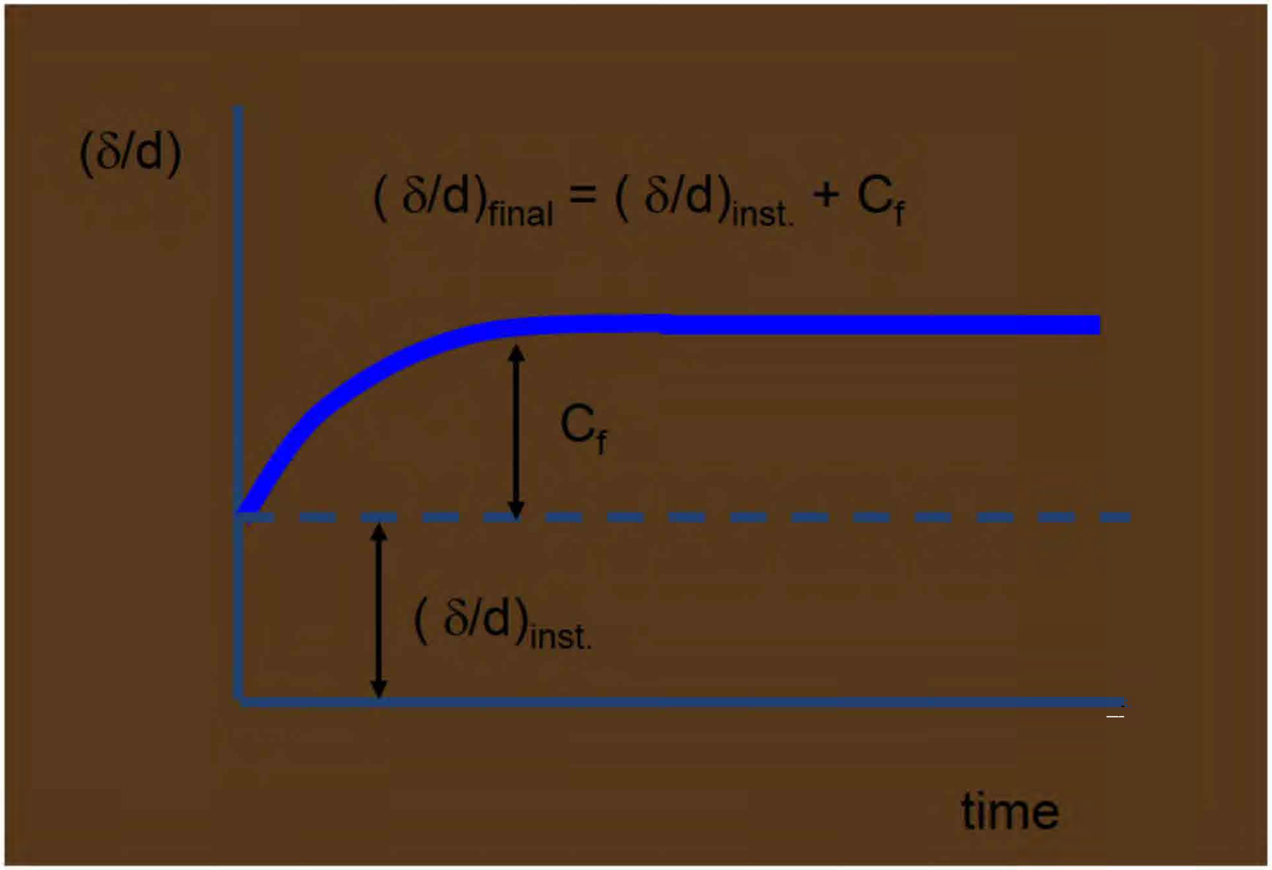
Final deflection



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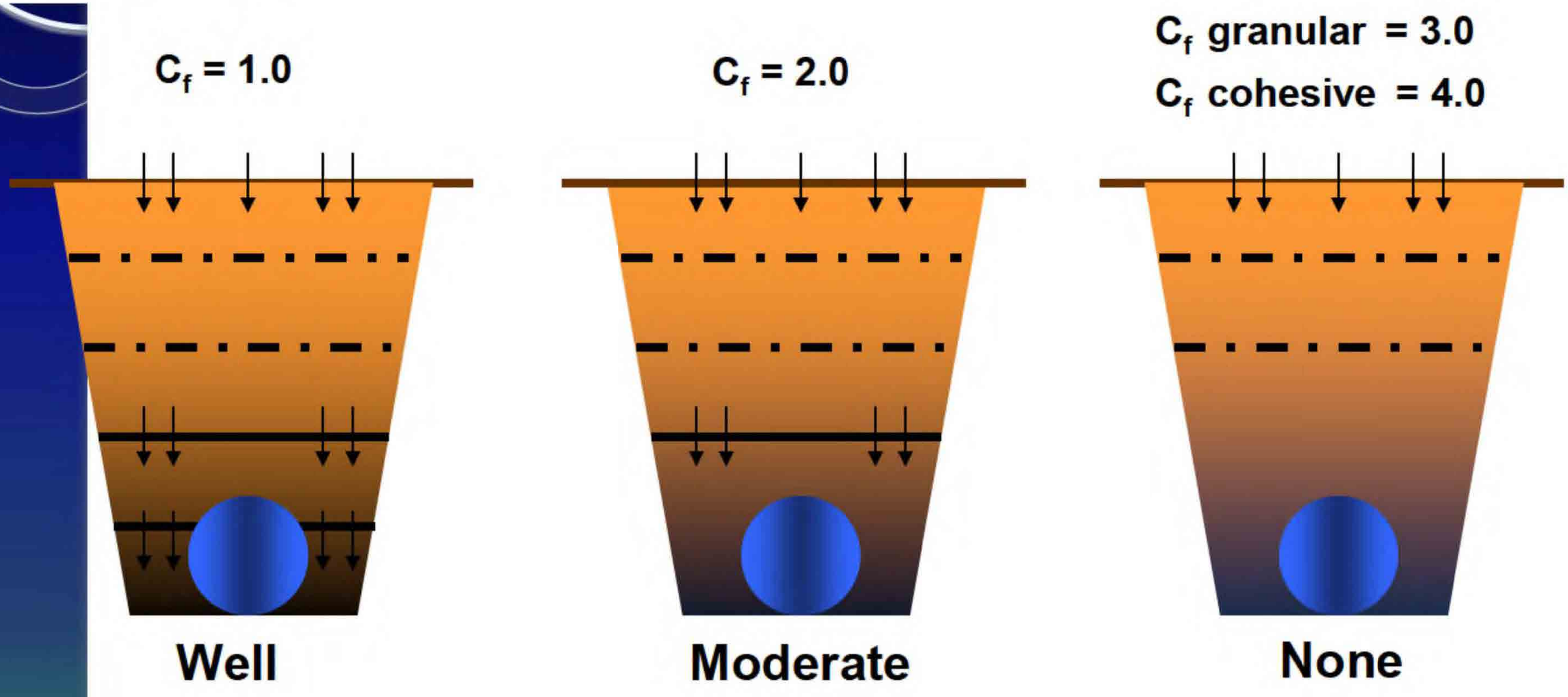
Installation practices used in the project



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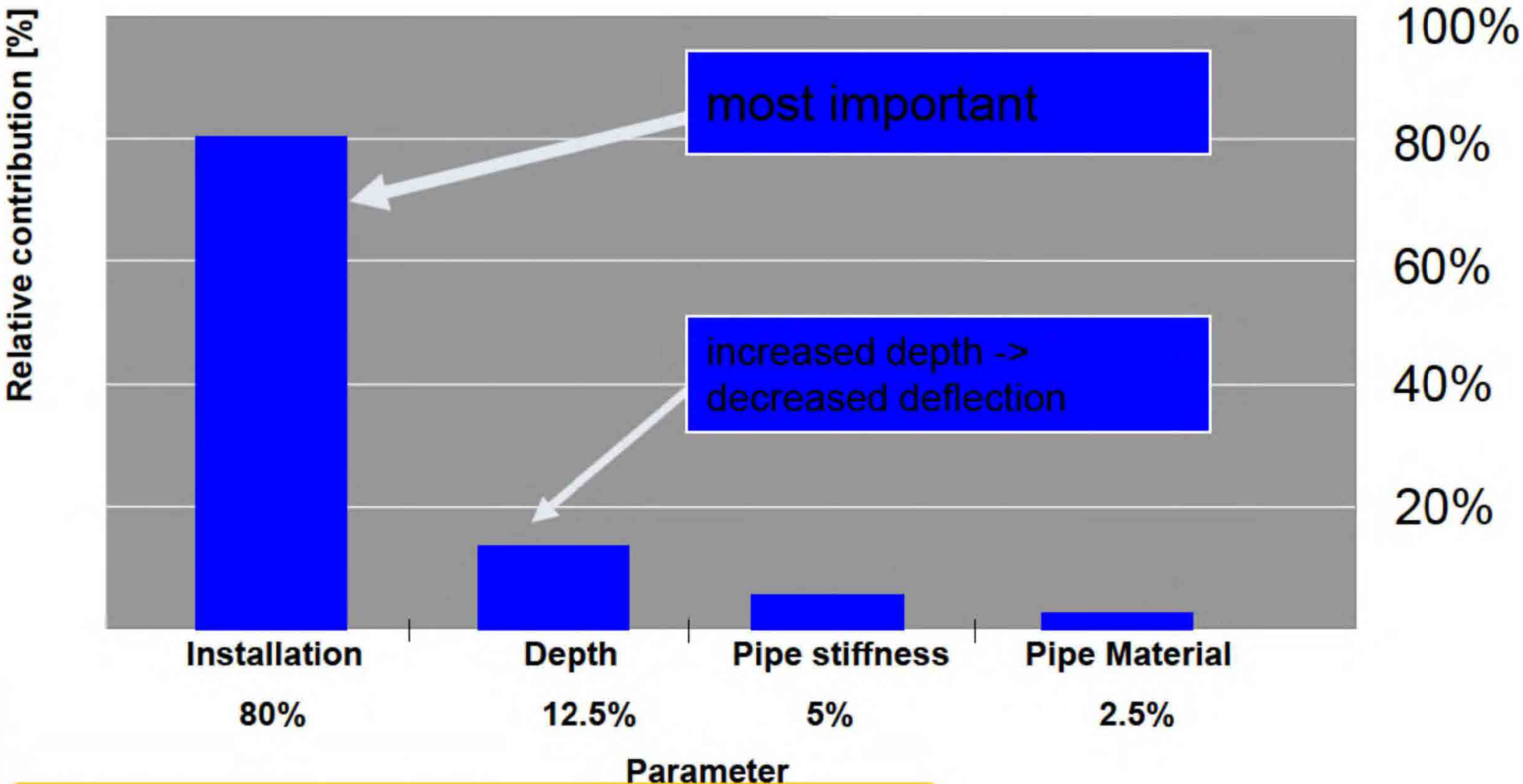
Effect of parameters on deflection



For a 10% deflected pipe

8 % installation and design of bedding and backfill
1.25 % Depth of installation
0.5 % Pipe stiffness
0.25 % E modulus of the material

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Conclusions

- Depth and traffic load have no effect on the final deflection.

- For "Well" to "Moderate" type of installation:
  - pipe stiffness not important
  - creep ratio / material not important
  - deflections stay very low
  - limit state conditions are not likely to occur.

Note: Proven for pipes in the stiffness range 2 to 16 kN/m^2.

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Conclusions

- Depth and traffic load have no effect on the final deflection.

- For “Well” to “Moderate” type of installation:
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Note: Proven for pipes in the stiffness range 2 to 16 kN/m^2.

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Under what conditions are the above the case ?

The graph is applicable when the following conditions are fulfilled.

Table 10 — Application of the design graph; checking pipe installations within this design graph fulfils 4.2 of EN 1610:1997 [13]

Parameter	Value (range)	Remark
Installed depth	0,80 m to 6,0 m	Cover depth to crown
Soils	Granular-cohesive	
Installation type	Well, moderate, none	Combination of soil, compaction, and degree of care
Pipe stiffness, SN (EI/D^3)	≥ 2 kN/m^2	
Pipe types, structured and solid wall	Solid wall pipes Structured wall pipes fulfilling the 30 % ring flexibility test	Also applies to solid wall pressure pipes
Traffic load	all cases	
Diameter	≤ 1 100 mm	
Depth of cover / diameter ratio	≥ 2	
Ground water table	No limitation	

NOTE 1 National calculation methods and regulations, as mentioned in Annexes A and B of EN 1295-1, might put additional limitations. See therefore the national foreword.

NOTE 2 Pipe stiffness less than 4 kN/m^2 is sometimes used for pipes with diameters bigger then 800 mm.

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Under what conditions are the above the case ?

Table C.1 — Validity of the design graph

Pipe system	Fulfilling requirements in ISO 8772, ISO 8773, ISO 4435, ISO 21138-1 (this document), ISO 21138-2 and ISO 21138-3 as applicable
Installation depth	0,8 m to 6,0 m
Traffic loading	Included
Installation quality Installation categories "well", "moderate" (and "non-") should reflect the workmanship on which the designer can rely.	**"Well" compaction (I)** The embedment soil of a granular type is placed carefully in the haunching zone and compacted, after which the soil is placed in shifts of maximum 30 cm, after which each layer is compacted carefully. The pipe shall at least be covered by a layer of 15 cm. The trench is further filled with soil of any type and compacted. Typical values for the proctor density are above 94 %.
	"Moderate" compaction (II) The embedment soil of a granular type is placed in shifts of maximum 50 cm, after which each layer is compacted carefully. The pipe shall at least be covered by a layer of 15 cm. The trench is further filled with soil of any type and compacted. Typical values for the proctor density are in the range of 87 % to 94 %.
	Note = Sheet piles should be removed before compaction, in accordance with the recommendations in EN 1610:1997. If, however, the sheet piles are removed after compaction one should realise that the "well" or "moderate" compaction level will be reduced to the "non-" compaction level (III).
Additional	National rules can apply.

C.3 Structural design based on design calculations

When structural design is required, e.g. in cases where no other information exists, then a method as defined in EN 1295-1 should be used. If input values for the pipes are required, the values given in Table A.1 are recommended.

Unless otherwise agreed between the specifier and the system owner it is recommended that, for reasons of serviceability, the calculated average deflection values do not exceed the values given in Table C.2.

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Under what conditions are the above the case ?

Construction and testing of drains and sewers;
English version EN 1610:2015,
English translation of DIN EN 1610:2015-12

4.2 Safeguarding design decisions

In the execution of the work it shall be ensured that the decisions made in the design are complied with or adapted to changed conditions.

The design decisions may be affected by variation of any of the following which should be checked during installation:

— trench width (see 6.3);

— trench depth;

— trench support system and the effect of its removal (see 11.5);

— degree of compaction of the embedment;

— degree of compaction of main backfill;

— pipe support and trench bottom conditions;

— construction traffic and assumptions concerning temporary loads;

— soil types (e.g. subsoil, trench walls, initial and main backfill);

— shape of trench (e.g. stepped trench, trench with sloping walls);

— ground and soil condition (e.g. affected by frost and thaw, rain, snow, flooding);

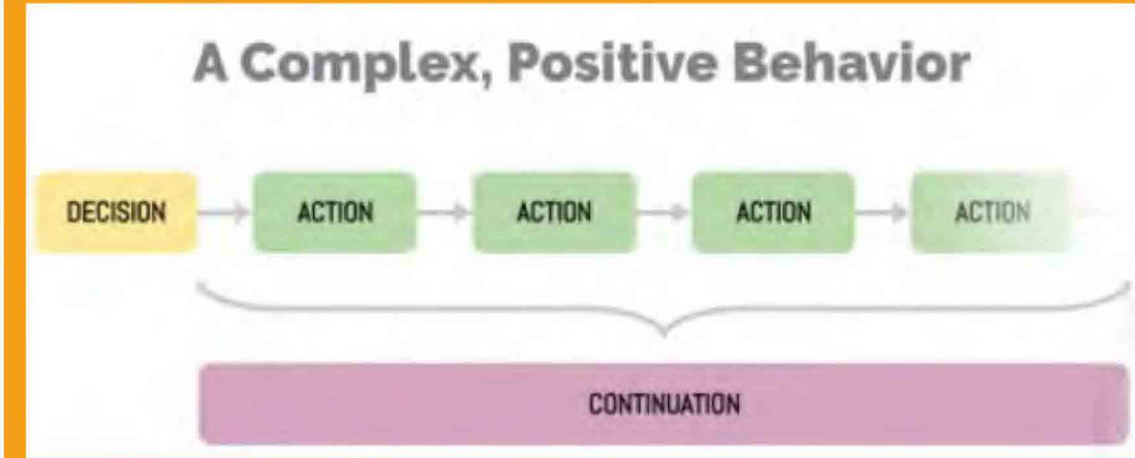
— ground water table;

— additional pipelines in the same trench;

— existing infrastructure (e.g. pipes, cables, structures);

— pipe type, strength or class.

NOTE The above list is not exhaustive.



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Standards and approaches

BRITISH STANDARD

BS EN 1295-1:1997

Incorporating corrigenda May 2006, July 2008, February 2010 and March 2010

Structural design of buried pipelines under various conditions of loading —

Part 1: General requirements

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN/TS 15223

April 2008

ICS 23.040.01

English Version

Plastics piping systems - Validated design parameters of buried thermoplastics piping systems

BS 9295:2010

BSI Standards Publication

Guide to the structural design of buried pipelines

EUROPEAN PRESTANDARD

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

ENV 1046

July 2001

ICS 23.040.01

English version

Plastics piping and ducting systems - Systems outside building structures for the conveyance of water or sewage - Practices for installation above and below ground

ENV 1046

English version

Plastics piping and ducting systems - Systems outside building structures for the conveyance of water or sewage - Practices for installation above and below ground

5.1.3 Design considerations

5.1.3.1 General

If it is essential to determine the soil conditions that relate to trench construction and pipe installation prior to construction, the native soil and the backfill material shall be classified in accordance with Annex A. The classification shall be used to choose a suitable pipe stiffness in accordance with 5.1.3.2.

NOTE The classification will also indicate the areas of suitable materials for pipe zone backfill, so that importation of material may be minimized. Native materials conforming to 5.1.6.3 and group 1, 2, 3 and 4 are all suitable as backfill in the pipe zone. If backfill materials have to be imported it is suggested that group 1 or 2 materials are used.

Installation

5 Installation

5.1 Pipes in trenches

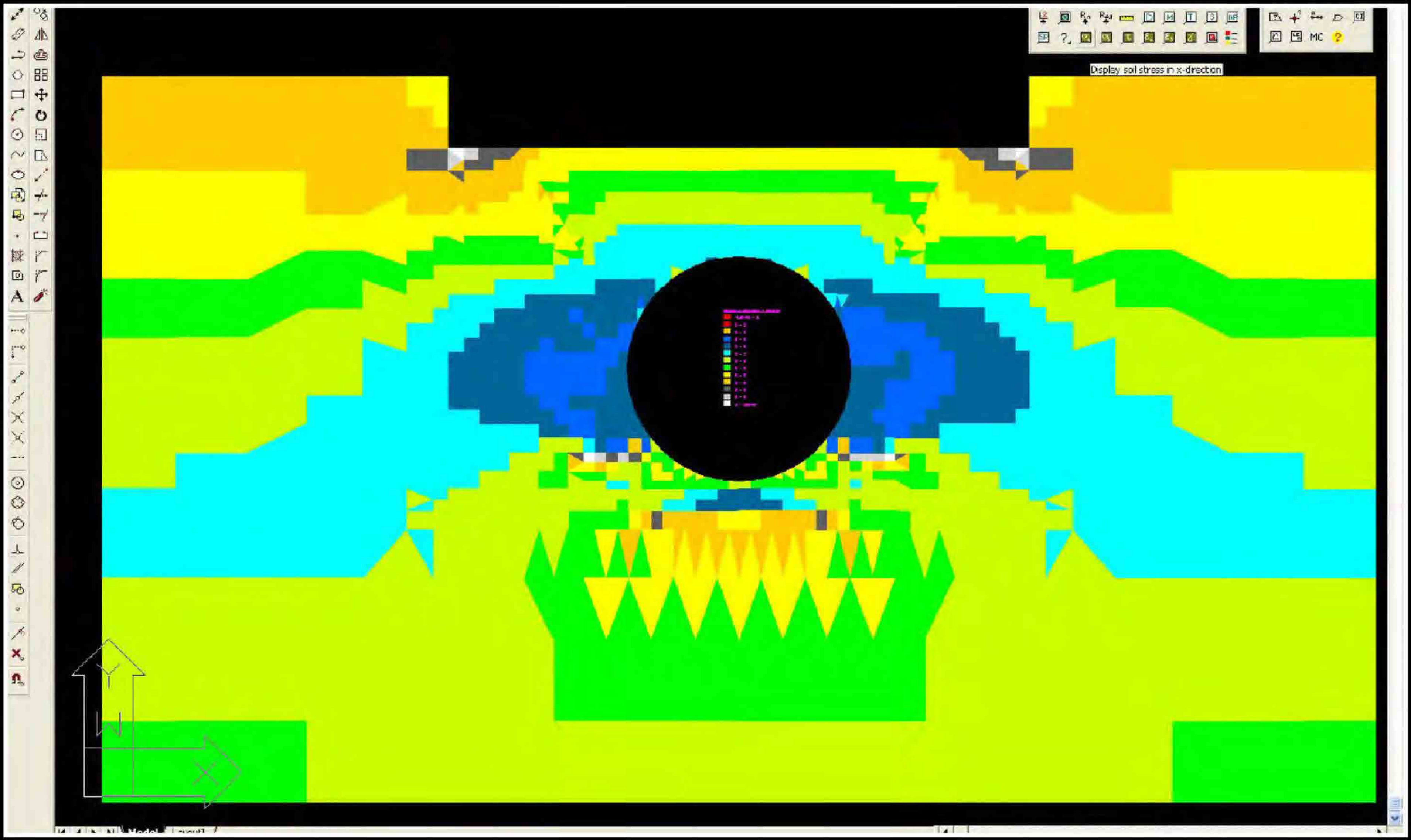
5.1.1 Behaviour of flexible pipes under load

The behaviour of a pipe when subject to a load depends upon whether it is flexible or rigid. Plastics pipes are flexible. When loaded a flexible pipe deflects and presses into the surrounding material. This generates a reaction in the surrounding material which controls deflection of the pipe. The amount of deflection which occurs is limited by the care exercised in the selection and laying of the bedding and sidefill materials. Hence flexible pipes rely for their load-bearing properties on the bedding and sidefill materials.

In the case of rigid pipes, the load on a pipe is borne primarily by the inherent strength of the pipe material and when this load exceeds a limiting value the pipe breaks. Standards for rigid pipes, therefore, usually include ultimate crushing strength tests to determine this limiting value and thus assess the loadings which may be allowed above the installed pipe.

Flexible pipes on the other hand deflect under load and can be deflected to a high degree without fracture. The level of deflection reached by a buried pipe depends on the properties of the surrounding material and to a much less extent on the stiffness of the pipe but not on its strength properties. Hence for flexible pipes the crushing strength test and design procedures applied to rigid pipes are not appropriate.

When a flexible pipe is installed and backfilled it will be deflected. This is called the initial deflection. The pipe continues slowly to have an increase in deflection but reaches a limiting value within a reasonable period of time. The use of the installation procedures detailed in this prestandard will minimize the levels of both the initial and final deflections. If the pipeline is pressurized then a reduction in the amount of deflection will occur. A more detailed description of this behaviour is given in Annex C.


Display soil stress in x-direction

Choice of pipe stiffness

5.1.3.2 Choice of pipe stiffness

The choice of pipe stiffness shall be made either using the tables in this prestandard or on the basis of calculations in accordance with EN 1295-1:1997 or on the basis of previous experience.

Where calculations show that a pipe stiffness lower than that given in Table 1 or Table 2 is appropriate, then pipes with this lower stiffness may be used. Where pipes are intended to be used in conditions where they have by previous experience proved to be satisfactory it is not necessary to verify this by detailed calculation even though their stiffness may be lower than the appropriate value given in Table 1 or Table 2.

If such experience is not available then the minimum stiffness required shall be selected from Table 1 or Table 2. These tables have been prepared to cover the following conditions:

a) non-trafficked areas with depths of cover between 1 m and 3 m and between 3 m and 6 m see Table 1);

b) trafficked areas with depths of cover between 1 m and 3 m and between 3 m and 6 m (see Table 2).

In the absence of prior satisfactory experience, where pipes have a depth of cover less than 1 m or more than 6 m the pipe stiffness and the installation shall be designed by calculation.

Where a System Standard uses SDR for classification purposes instead of stiffness it shall also give the equivalent stiffness values in its relevant part.

Generally the choice of pipe stiffness depends upon the native soil, the pipe zone backfill material and its compaction, the depth of cover, the loading conditions and the limiting properties of the pipes.

In order to make a choice of pipe stiffness possible, the native soil and backfill materials have been classified into six main groups as described in Annex A.

Based on the native soil, backfill details and depth of cover, the minimum pipe stiffness is selected from Tables 1 or 2. Using a pipe of this stiffness installed in an embedment formed from the appropriate backfill material compacted to the specified degree of compaction should result in deflections of not more than the limiting values given in the relevant System Standard.

Recommended minimum stiffness for non-trafficked areas

Table 1 — Recommended minimum stiffness for non-trafficked areas

Values in newtons per square metres

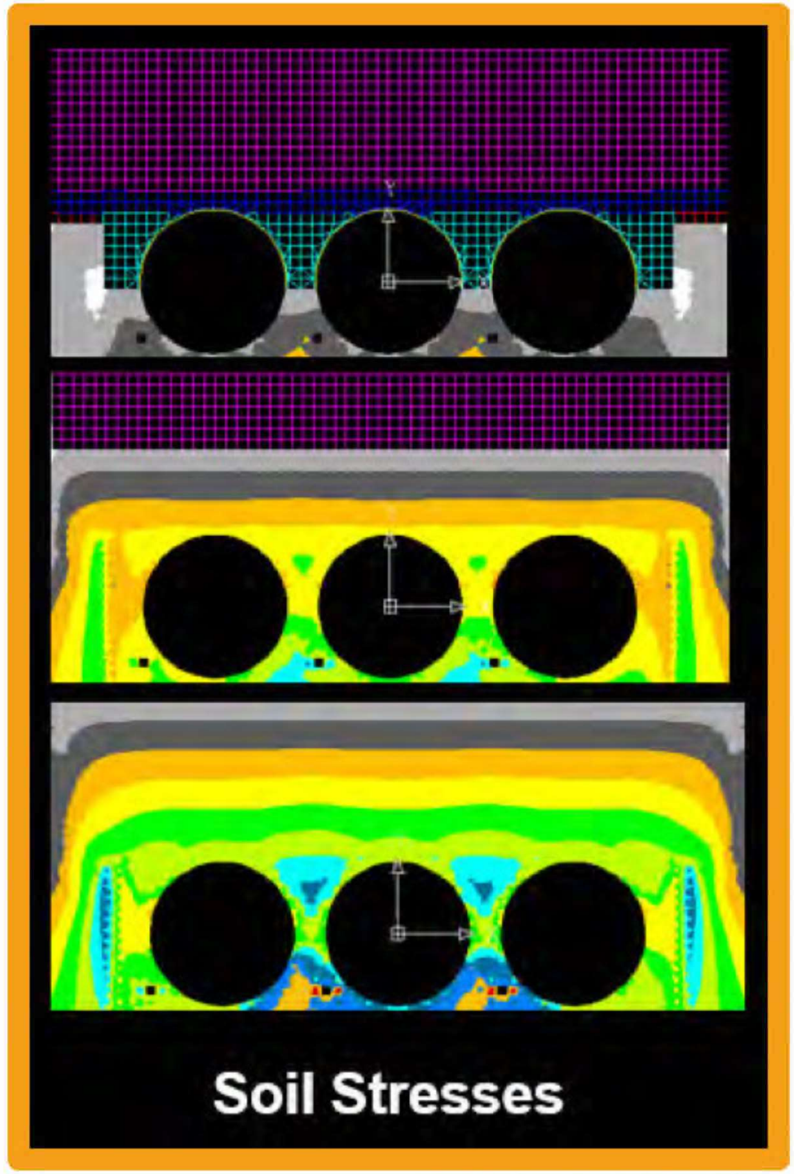
Backfill Material group 3)	Compaction-class 2)	Pipe stiffness 1)					
		For depth of cover ≥ 1 m and ≤ 3 m					
		Undisturbed native soil group 3)					
		1	2	3	4	5	6
1	W	1250	1250	2000	2000	4000	5000
	M	1250	2000	2000	4000	5000	6300
	N	2000	2000	2000	4000	8000	10000
2	W		2000	2000	4000	5000	5000
	M		2000	4000	5000	6300	6300
	N		4000	6300	8000	8000	**
3	W			4000	6300	8000	8000
	M			6300	8000	10000	**
	N			**	**	**	**
4	W				6300	8000	8000
	M				**	**	**
	N				**	**	**
		For depth of cover > 3 m and ≤ 6 m					
1	W	2000	2000	2500	4000	5000	6300
	M	2000	4000	4000	5000	6300	8000
2	W		4000	4000	5000	8000	8000
	M		5000	5000	8000	10000	**
3	W			6300	8000	10000	**
	M			**	**	**	**
4	W				**	**	**
	M				**	**	**

1) Initial specific stiffness, *S*, determined in accordance with the relevant System Standards
2) See Table 5.
3) See Annex A.
**) Structural design is necessary to determine trench details and pipe stiffness.

NOTE 1 If a pipe of given stiffness is intended to be used under more severe loading conditions (than originally envisaged), it may be possible to achieve this by the use of a higher class of installation. It is essential that this is verified by structural design.

NOTE 2 Attention is drawn to the limitations that may apply due to negative pressure in service and due to mechanical compaction requirements during installation for pipe stiffness up to and including SN 2500.

NOTE 3 In cases of combined loading conditions (such as soil load plus internal pressure) special considerations and possibly precautions should be taken.



Recommended minimum stiffness for trafficked areas

Table 2 — Recommended minimum stiffness for trafficked areas

Values in newtons per square metre

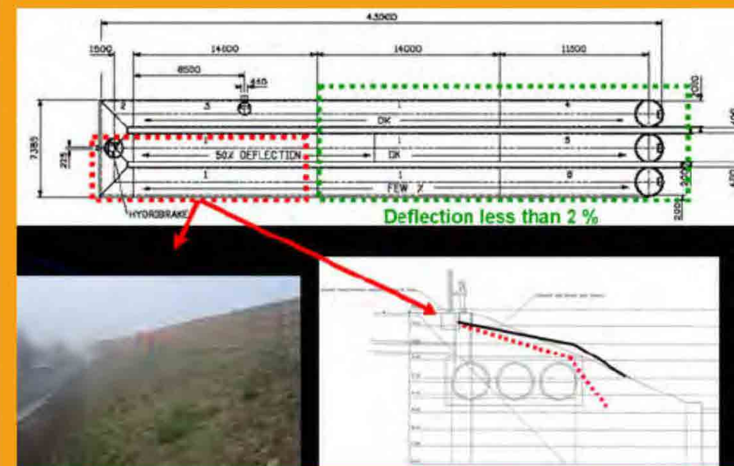
Backfill Material group 3)	Compaction class 2)	Pipe stiffness 1)					
		For depth of cover ≥ 1 m and ≤ 3 m					
		Undisturbed native soil group 3)					
		1	2	3	4	5	6
1	W	4000	4000	6300	8000	10000	**
2	W		6300	8000	10000	**	**
3	W			10000	**	**	**
4	W				**	**	**
		For depth of cover > 3 m and ≤ 6 m					
1	W	2000	2000	2500	4000	5000	6300
2	W		4000	4000	5000	8000	8000
3	W			6300	8000	10000	**
4	W				**	**	**

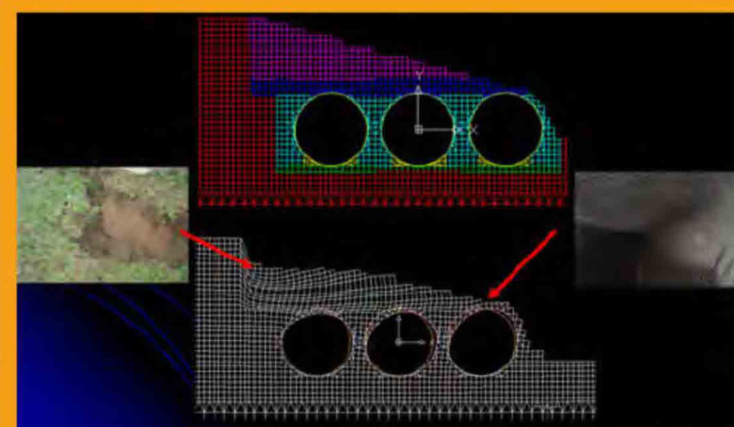
1) Initial specific stiffness, *S*, determined in accordance with the relevant System Standards
2) See Table 5.
3) See Annex A.
**) Structural design is necessary to determine trench details and pipe stiffness.

NOTE 1 If a pipe of given stiffness is intended to be used under more severe loading conditions (than originally envisaged) it may be possible to achieve this by the use of a higher class of installation. It is essential that this is verified by structural design.

NOTE 2 Attention is drawn to the limitations that may apply due to negative pressure in service and due to mechanical compaction requirements during installation for pipe stiffness up to and including SN 2500.

NOTE 3 In cases of combined loading conditions (such as soil load plus internal pressure) special considerations and possibly precautions should be taken.





SDR Equivalent Pipe Ring Stiffness

	SDR		
	SN2	SN4	SN8
PE80	36.41	29.11	23.30
PE100	39.58	31.62	25.31
PVC250	55.14	43.97	35.10
SANS966-1	50.65	40.41	32.28
PVC HI	50.87	40.58	32.41
PVC500	56.78	45.27	36.14
PP-R	37.36	29.86	23.90
PP-H	40.84	32.61	26.10
PP-B	40.84	32.61	26.10
PP-HM	45.14	36.03	28.81

$$SDR = \frac{d_e}{e}$$

Equation 4.3

SDR = standard dimension ratio (-)
d_e = rounded outside diameter of the pipe (mm)
e = pipe wall thickness (mm)

Pressure

1 Kilonewton / Square meter = 1000 Newton / Square meter

Table 19 — Minimum required marking of pipes

Information	Marking or symbols
Number of this document	ISO 21138-2
Diameter series nominal size/actual guaranteed min. inside diameter[a] for: DN/OD series DN/ID series	 DN/OD 200/178 DN/ID 180/178
Manufacturer's name and/or trade mark	XYZ
Stiffness class	e.g. SN 8
Material	Either PVC-U, PVC[b], PP or PE
MFR class[c]	e.g. MFR-B
Manufacturer's information	[d]
Low temperature installation performance	❄ (ice crystal symbol)[e]
Close tolerance class	CT[f]

9 Calculation of ring stiffness

Calculate the ring stiffness, S_a, S_b and S_c, of each of the three test pieces (a, b and c, respectively), in kilonewtons per square metre, using the following formulae:

$$S_a = \left(0{,}018\,6 + 0{,}025\frac{y_a}{d_i}\right)\frac{F_a}{L_a y_a} \times 10^6 \quad (3)$$

$$S_b = \left(0{,}018\,6 + 0{,}025\frac{y_b}{d_i}\right)\frac{F_b}{L_b y_b} \times 10^6 \quad (4)$$

$$S_c = \left(0{,}018\,6 + 0{,}025\frac{y_c}{d_i}\right)\frac{F_c}{L_c y_c} \times 10^6 \quad (5)$$

where

F is the force, in kilonewtons, that corresponds to a 3,0 % pipe deflection;

L is the calculated average length of the test piece, in millimetres;

y is the deflection, in millimetres, that corresponds to a 3,0 % deflection, i.e.

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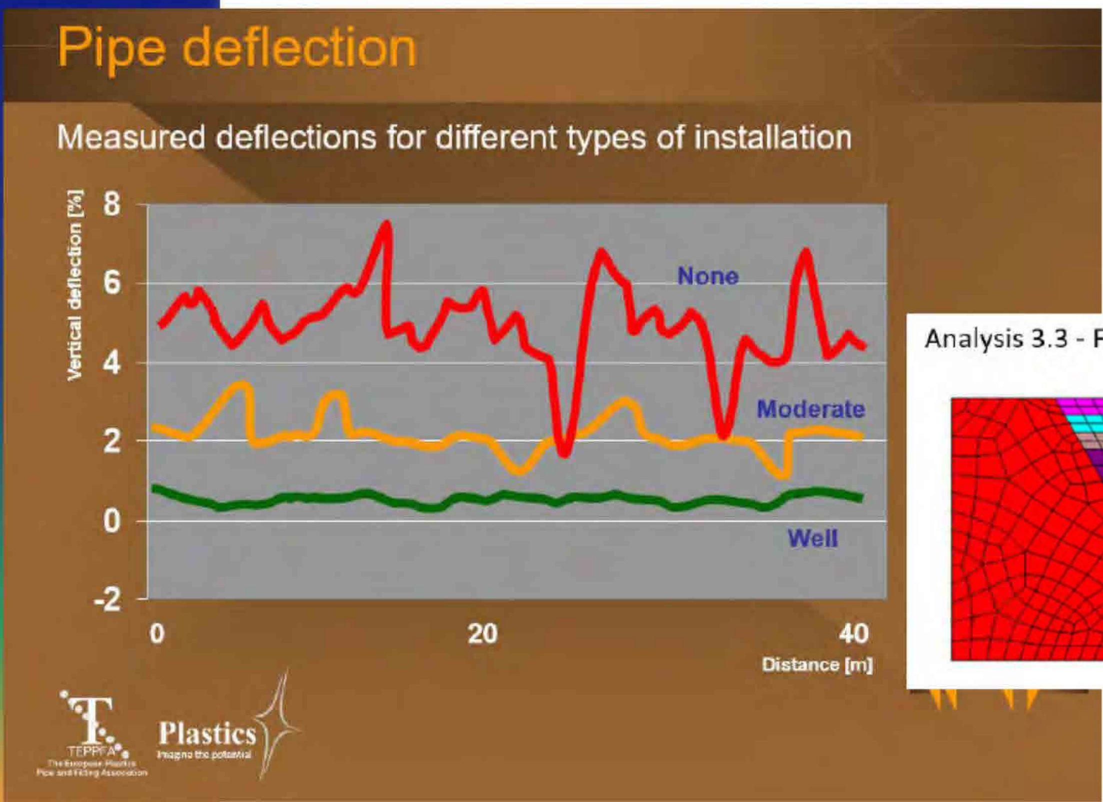
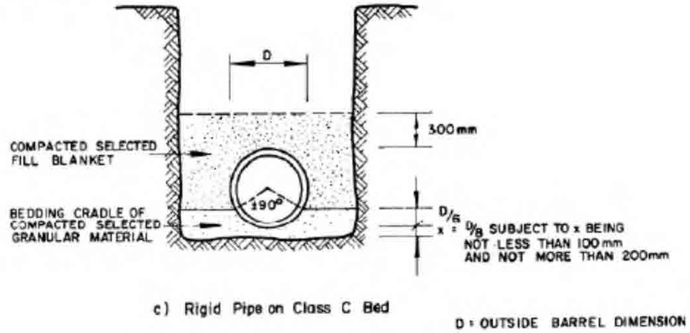
Recommended design deflections

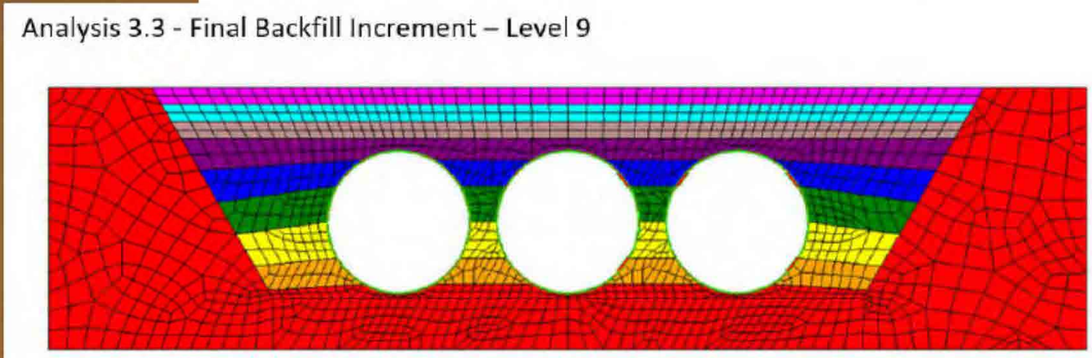
Table C.2 — Recommended design deflection limits

Stiffness class SN	Average initial deflection	Average long-term deflection
SN 2	5 %	8 %
SN 4, 8, 16	8 %	10 %

Check, Undo & Redo when deflection is too high







Let us bring it all together

More specifically, a person will very likely continue to engage in a new positive behavior if the ten conditions are met.

There are three conditions to meet in the **DECISION** phase:

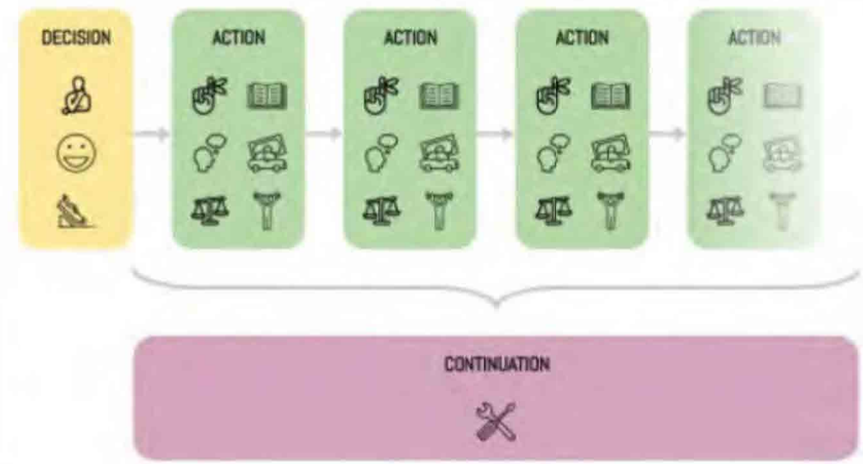
- Considers the behavior
- Desires to engage in the behavior
- Intends to engage in the behavior

There are six conditions to meet for every **ACTION**:

- Remembers to perform each action
- Believes attempting each action will help achieve a goal
- Chooses to perform each action over other available actions
- Knows how to perform each action
- Has needed resources and permission to perform each action
- Embodies skills and traits needed to perform each action

And there is one condition to meet for **CONTINUATION**:

- Maintains internal attributes and external conditions required to perform future needed actions



Questions and Answers

Ian Venter

20-04-2021

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Bringing it together, makes it work even better

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