Design of Buried Thermoplastics Pipes

Results of a European research project

by APME & TEPPFA

Civils 06-08

Design of Buried Thermoplastics Pipes

Results of a European research project

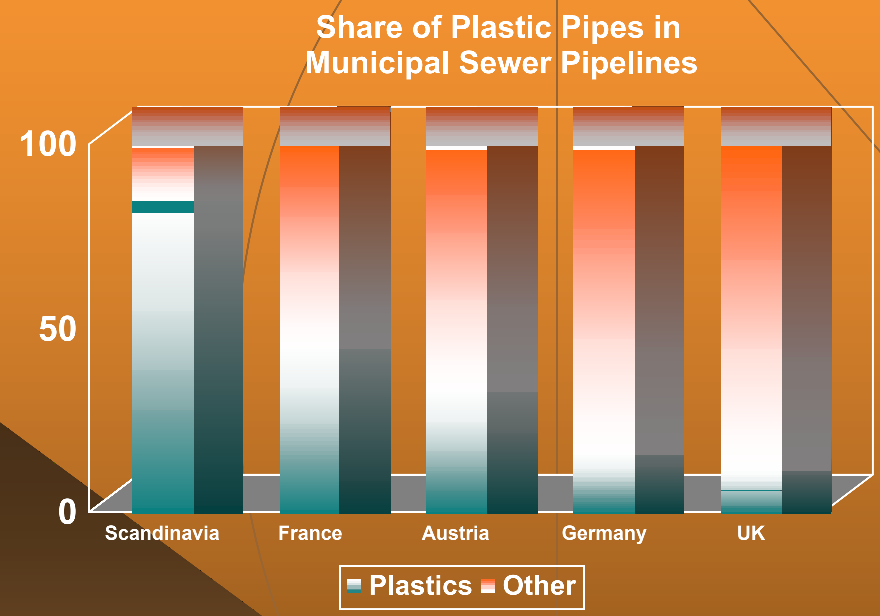
by APME & TEPPFA

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.



TEPPFA
The European Plastics Pipe and Fitting Association

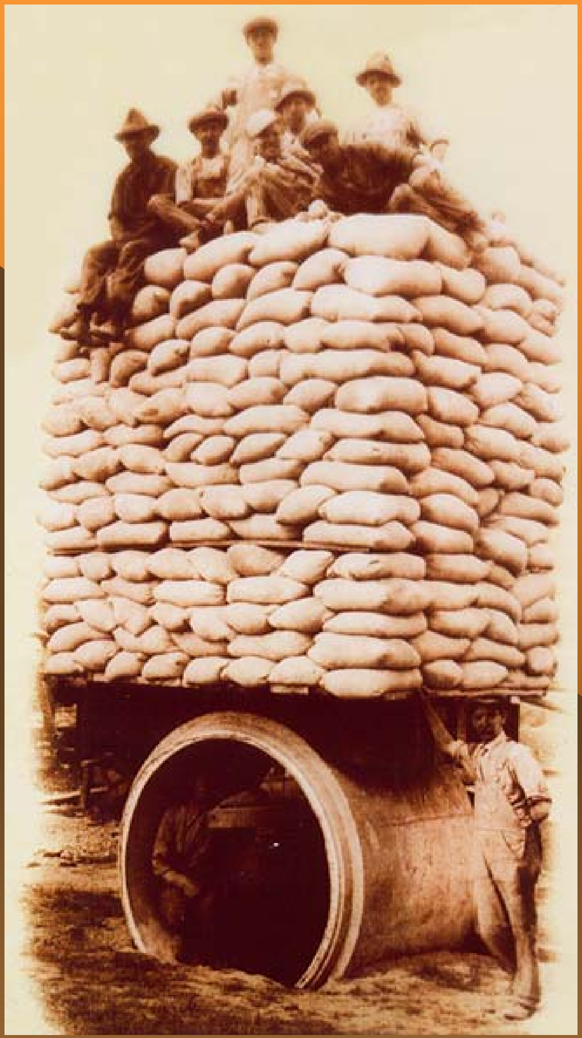
Plastics
Imagine the potential

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.

Try doing this with plastics



Source:

American Concrete Association

TEPPFA
The European Plastics
Pipe and Fitting Association

Plastics
Imagine the potential

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.

Project Group

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

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

TEPPFA
The European Plastics Pipe and Fitting Association
Plastics
Imagine the potential

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.

TEPPFA
The European Plastics Pipe and Fitting Association

Plastics
Imagine the potential

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)

Design of Buried Thermoplastics Pipes

Results of a European research project

by APME & TEPPFA

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

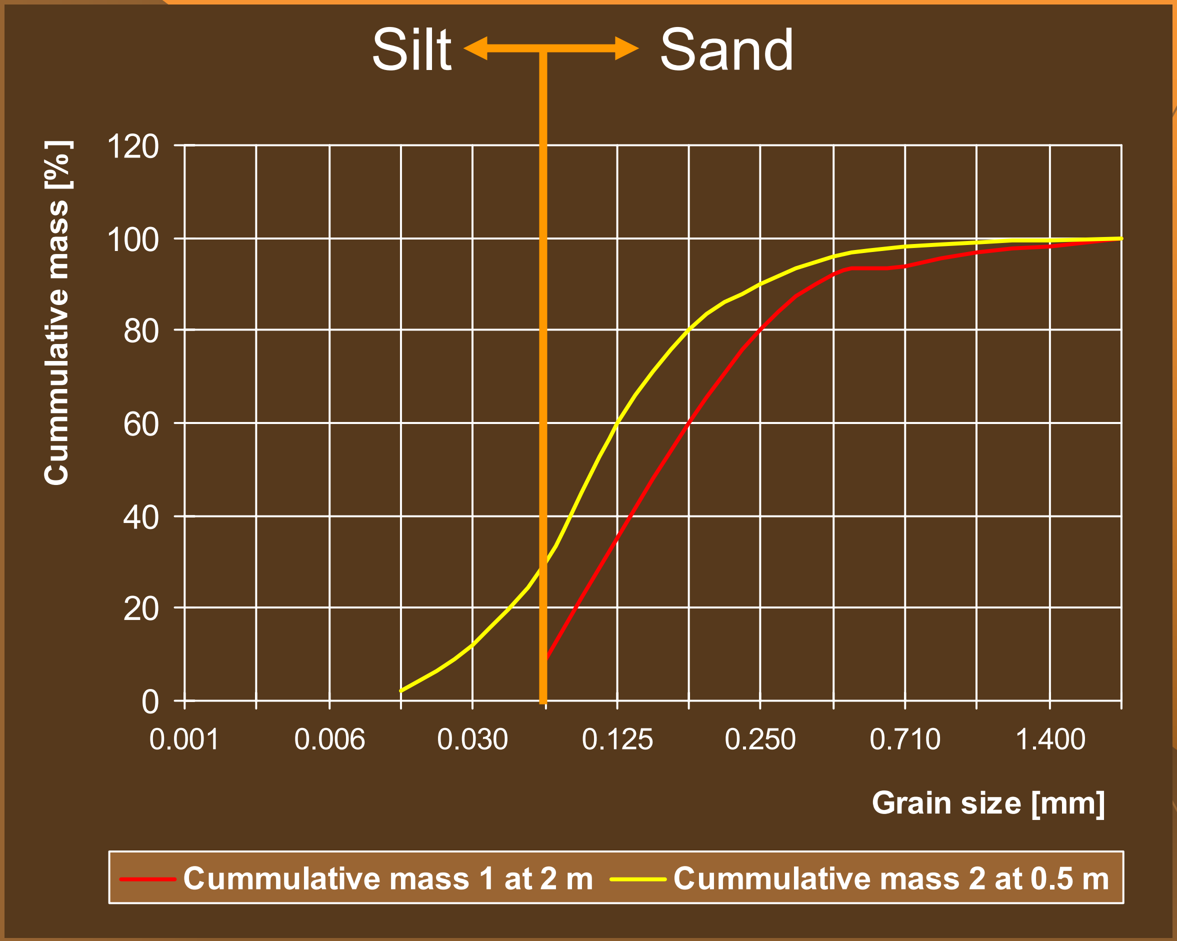
Documented test data

- 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

TEPPFA
The European Plastics Pipe and Fitting Association

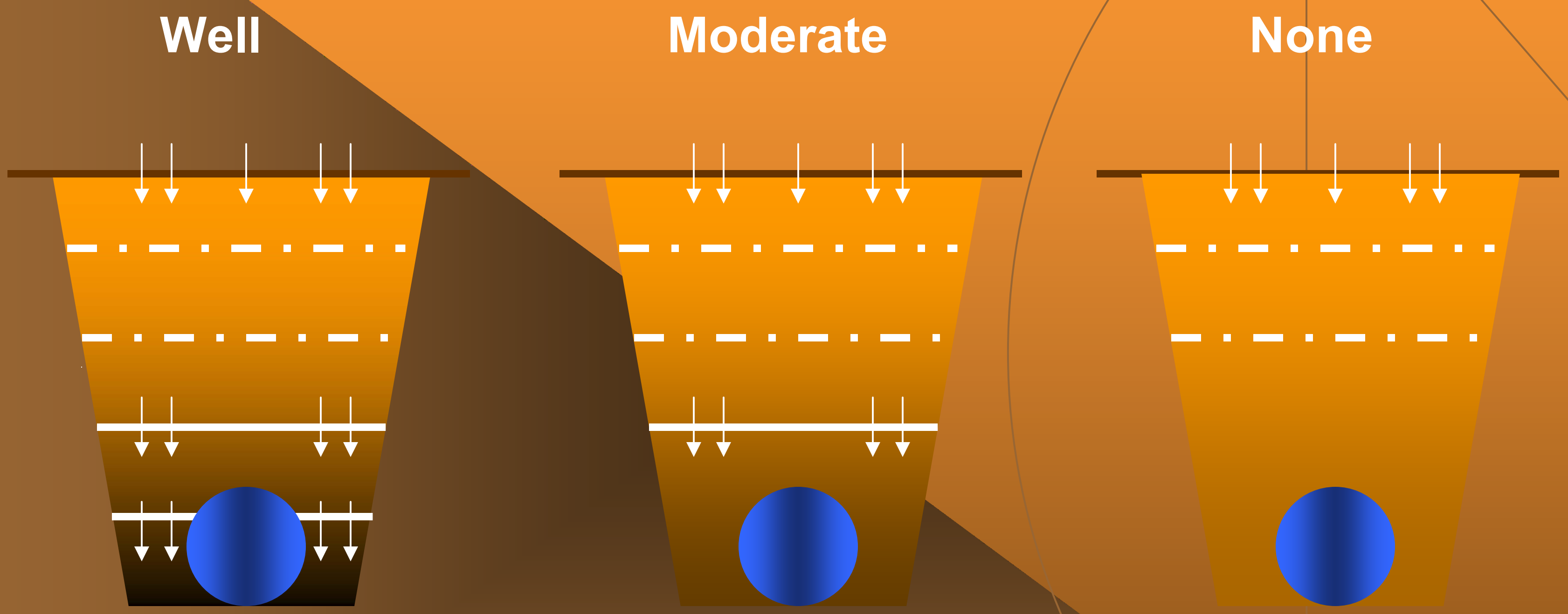
Plastics
Imagine the potential

Natural variations in soil



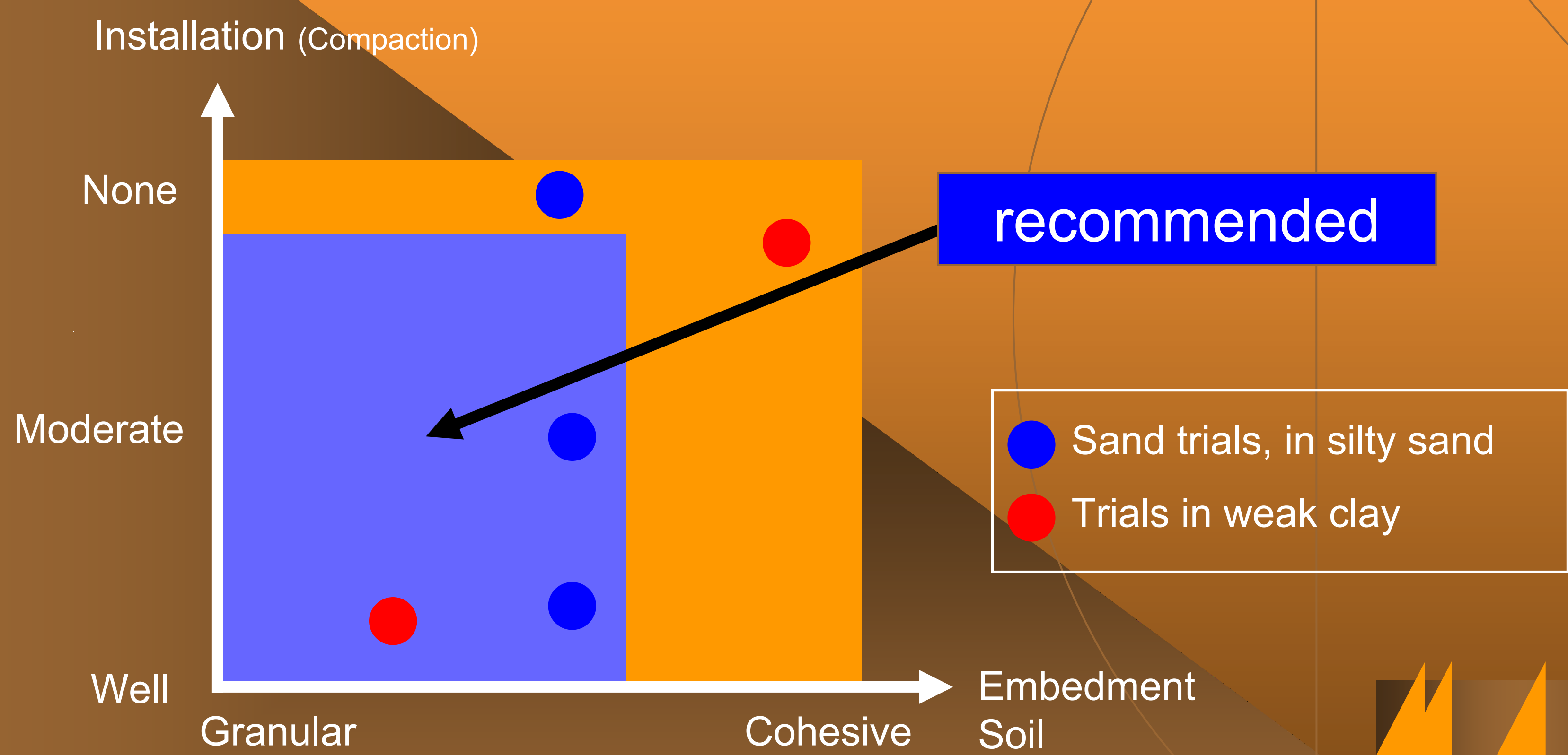
Grain size distributions of sand taken at two different depths

Installation practices used in the project



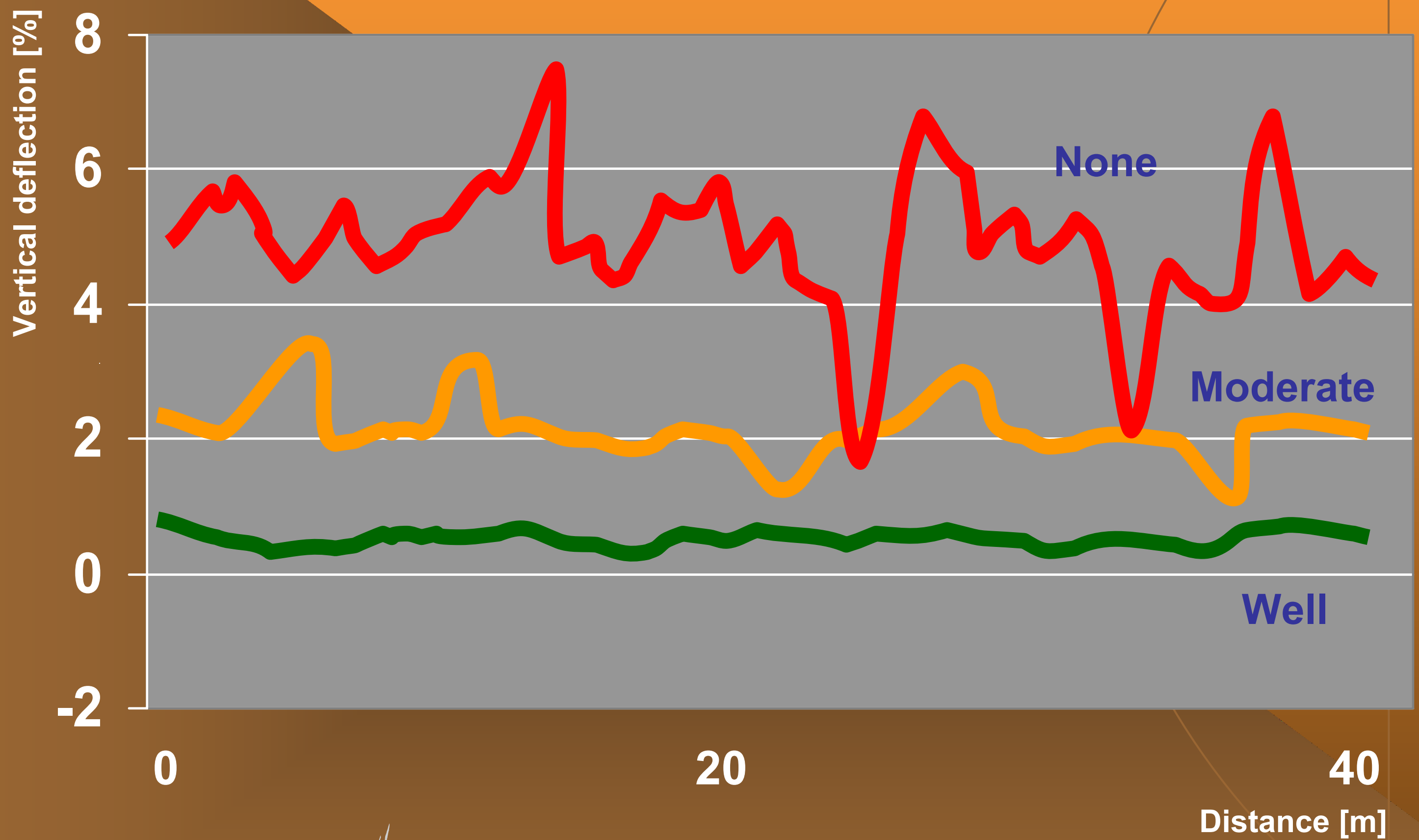
Position of trials

Position of trials in generalised application window



Pipe deflection

Measured deflections for different types of installation



TEPPFA
The European Plastics Pipe and Fitting Association

Plastics
Imagine the potential

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.”

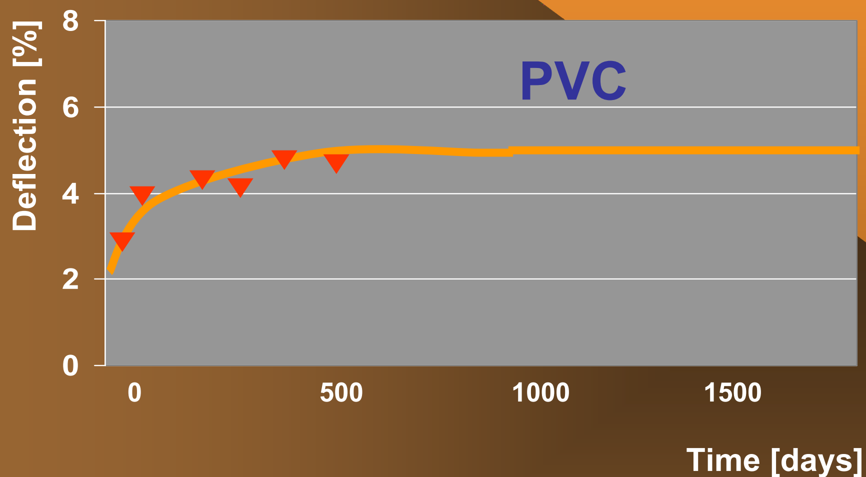
- “Consequently, the installation variability results in variations in ring deflection along the pipeline for flexible pipes and in variations in bending moments along the pipeline for rigid and semi-rigid pipes."

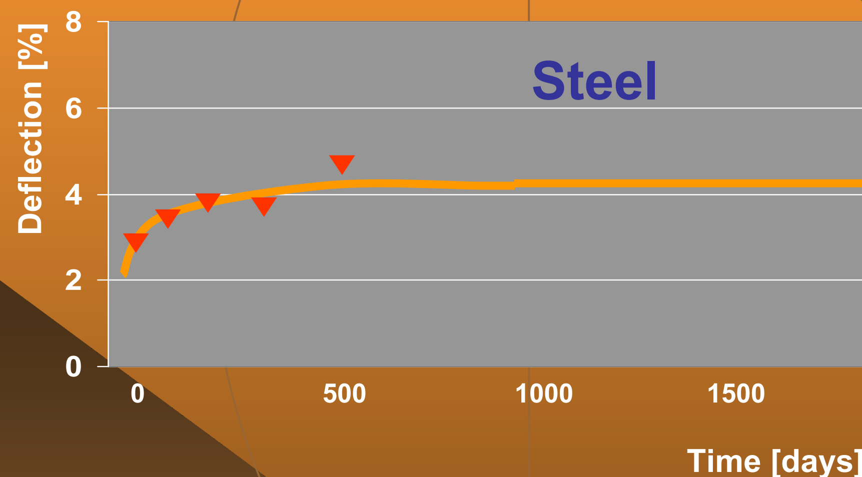
TEPPFA
The European Plastics Pipe and Fitting Association

Plastics
Imagine the potential

No difference between PVC / Steel

Time dependency of the deflection





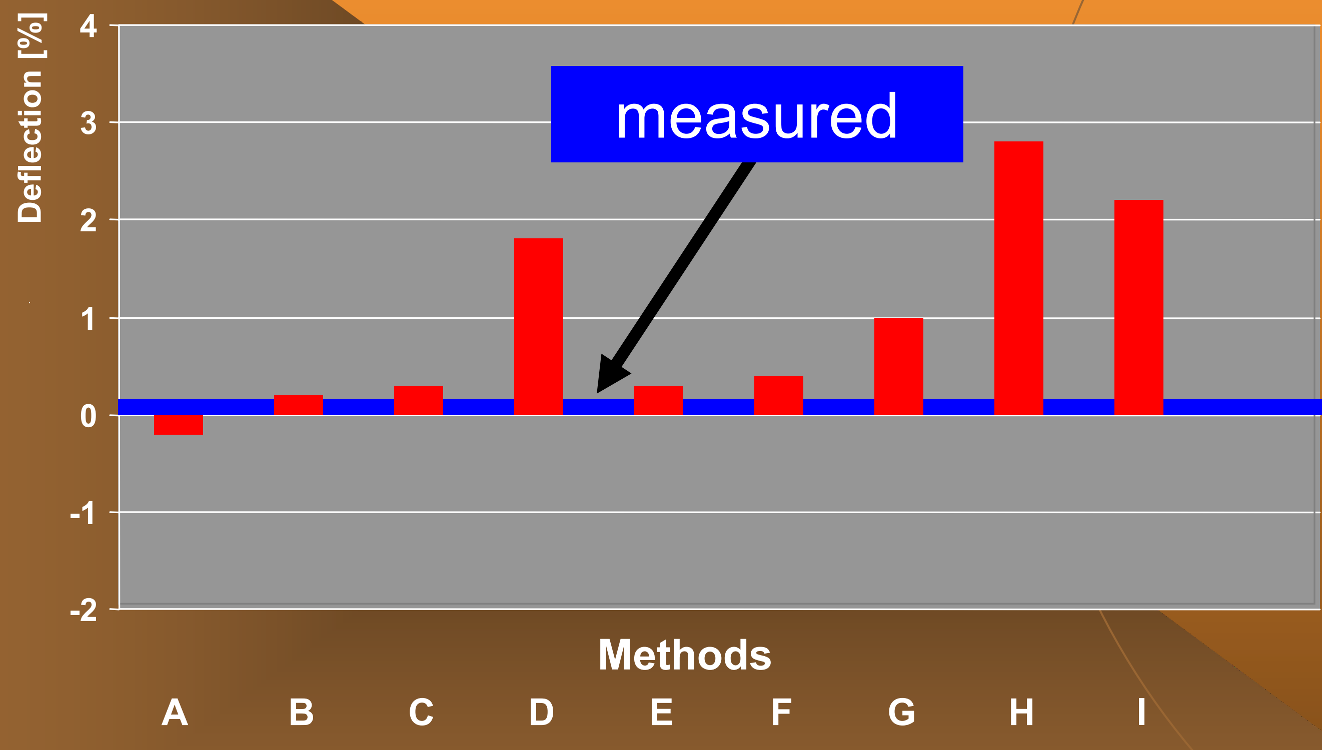
▼ Measured

TEPPFA
The European Plastics
Pipe and Fitting Association

Plastics
Imagine the potential

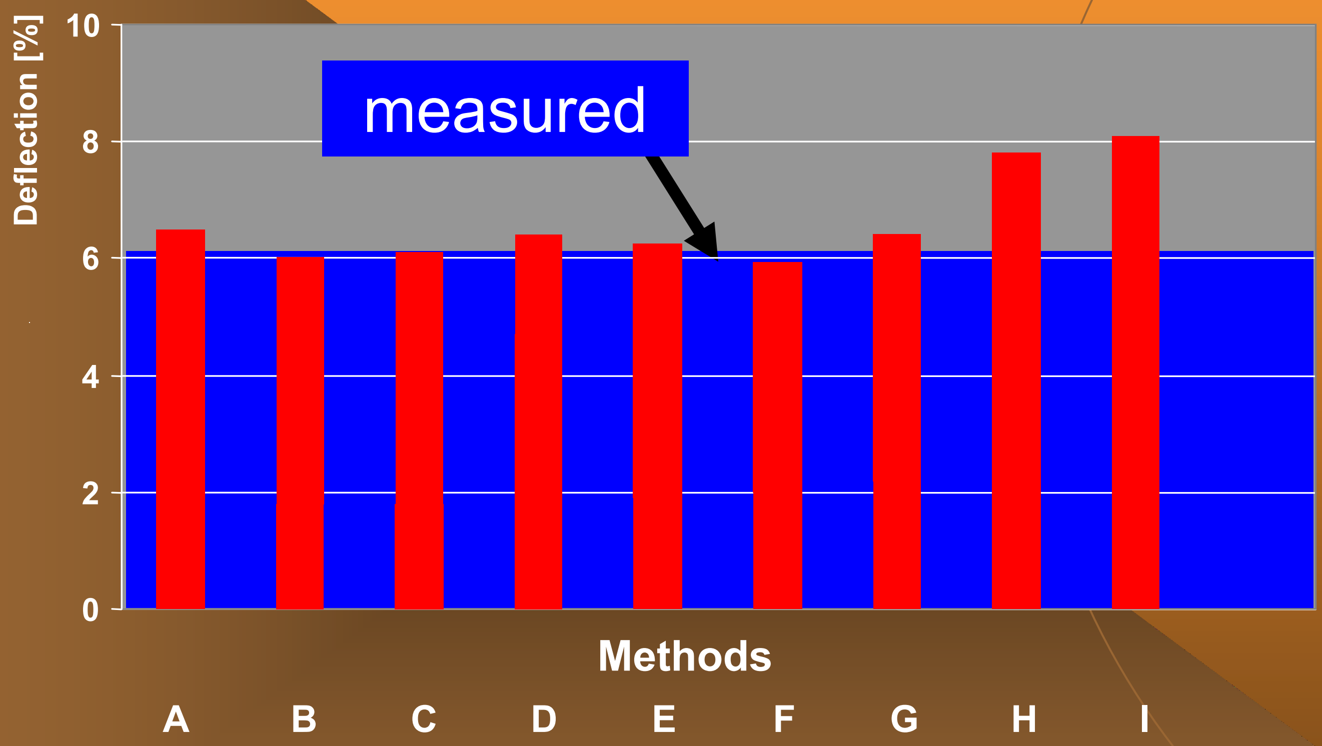
Calculated and measured deflections

Granular soil, good installation



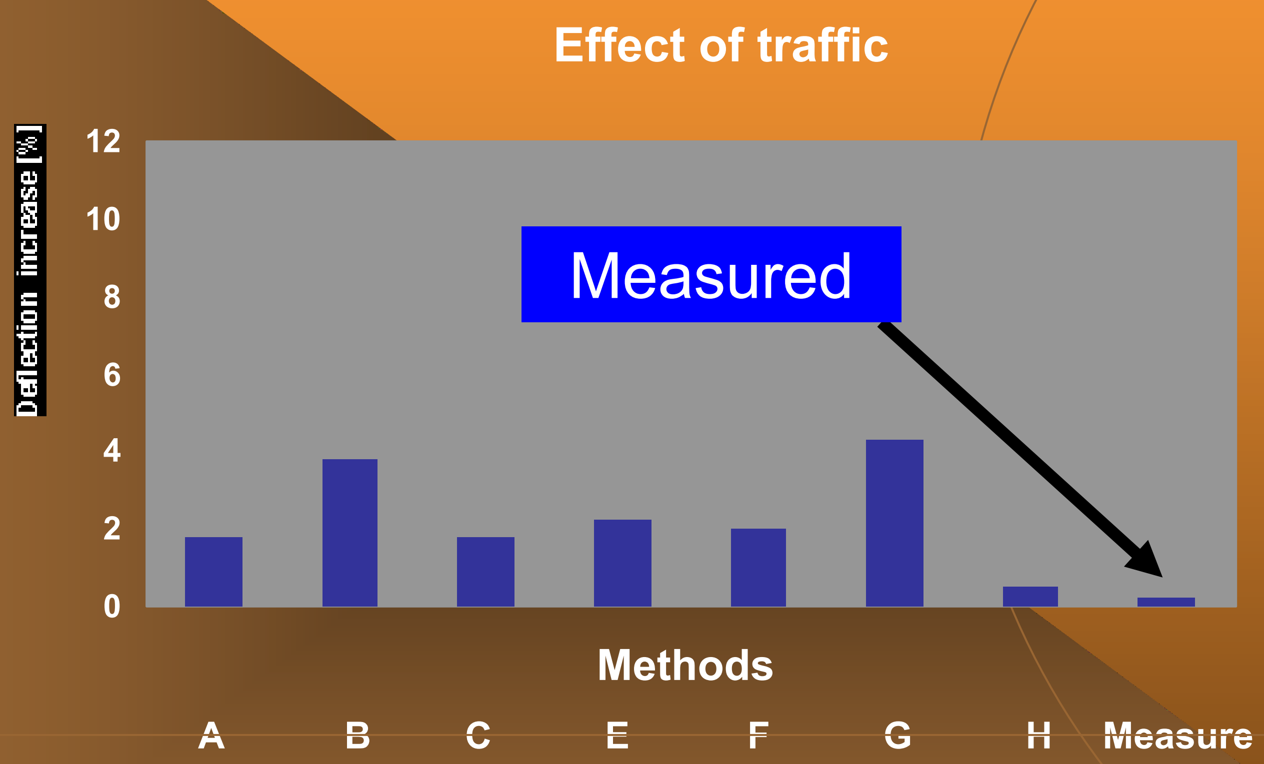
Calculated and measured deflections

Granular soil, poor installation



Calculated and measured deflections

Granular soil, poor installation with and without traffic load

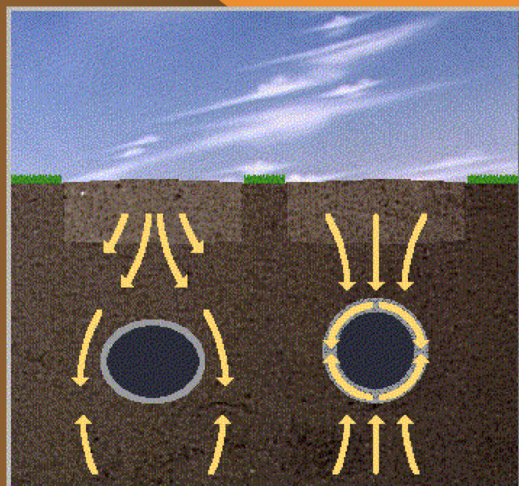


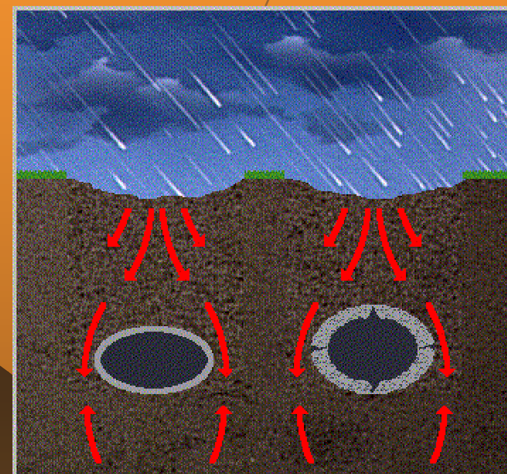
Summary of the main results

- 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.

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.





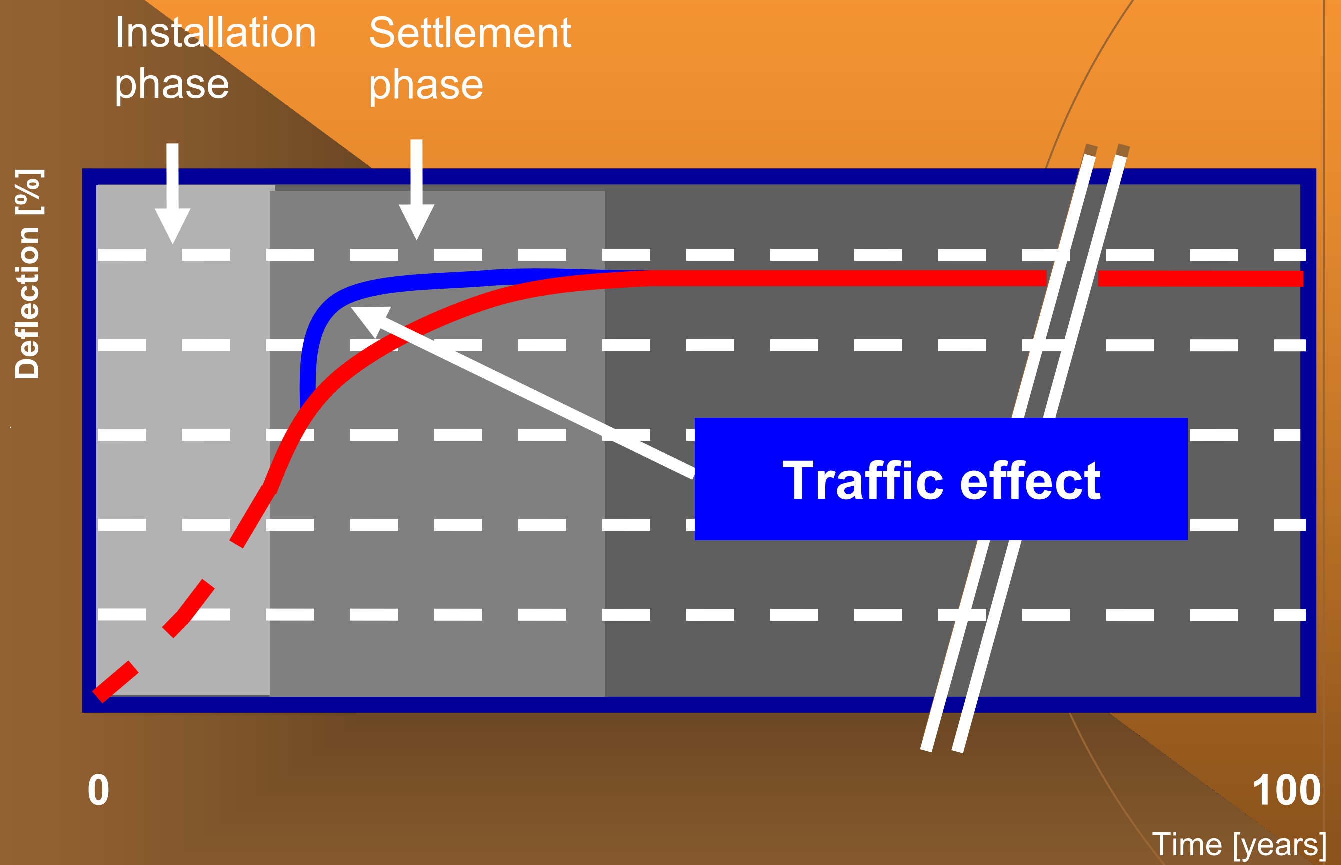
Deflection is safety!

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 it's variation depends more on the installation quality than on the pipe stiffness.

Facts about deflection



Facts about deflection

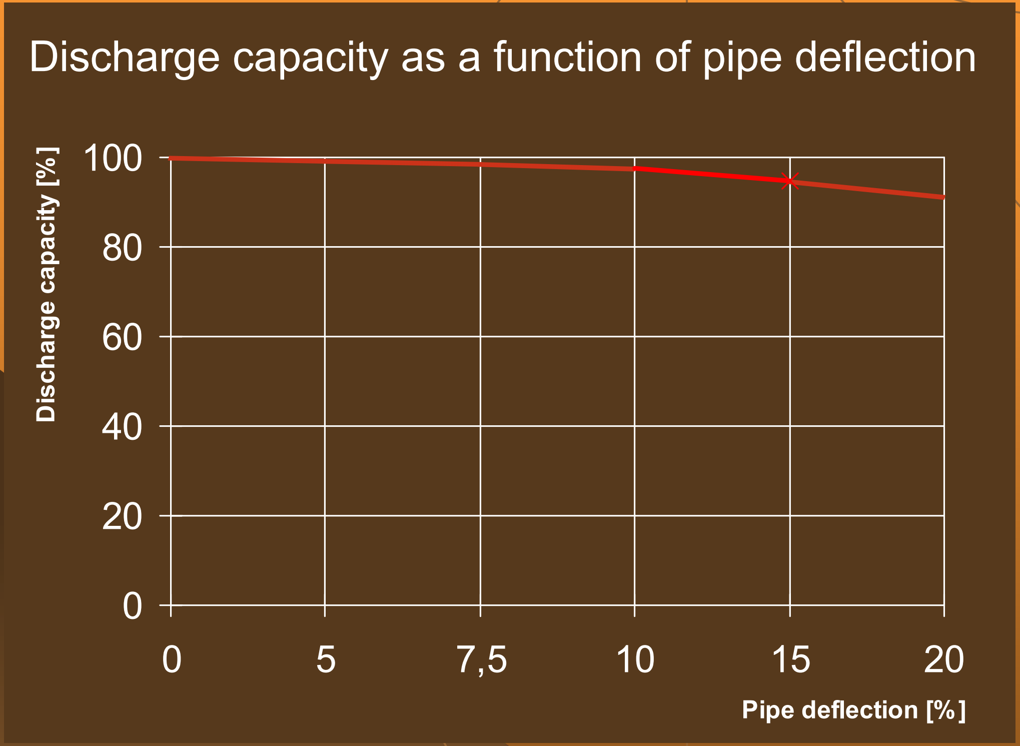
- Recommended max. values :

  8% initial, 12.5 % final.

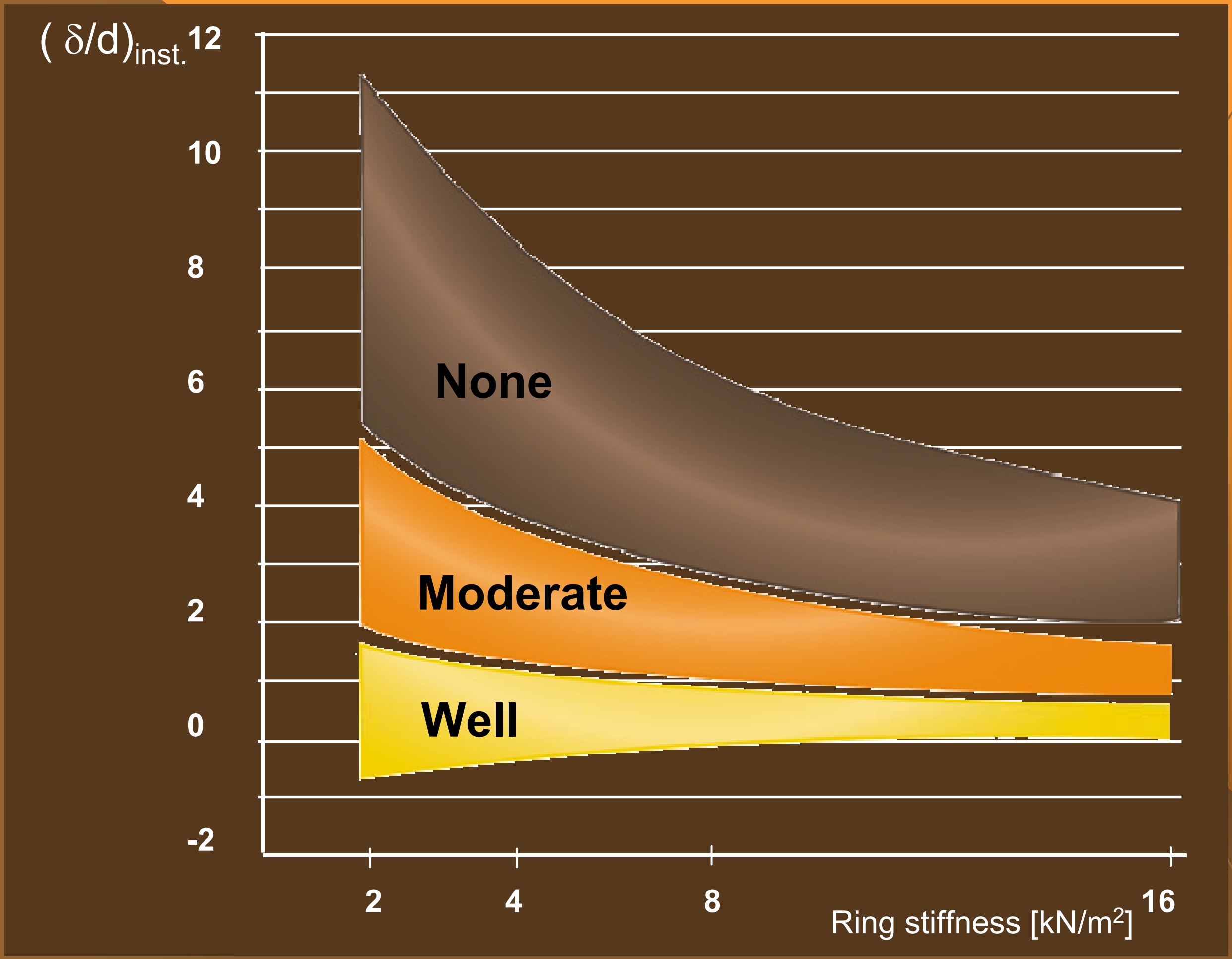
  (ISO TR 7073)

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

Deflection is NO issue!

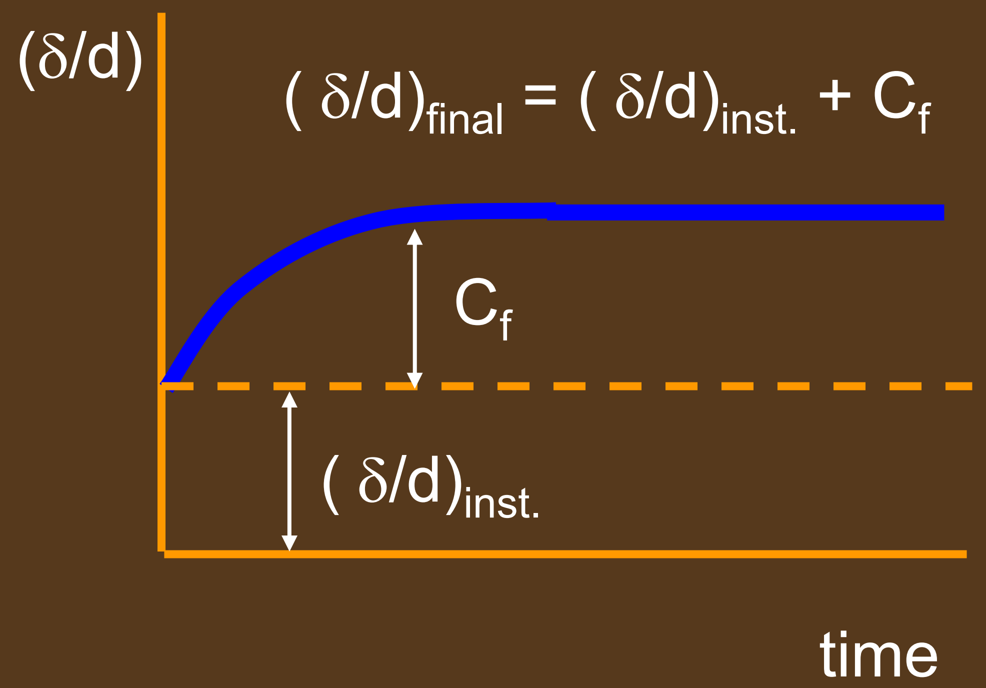


Pipe deflection after installation

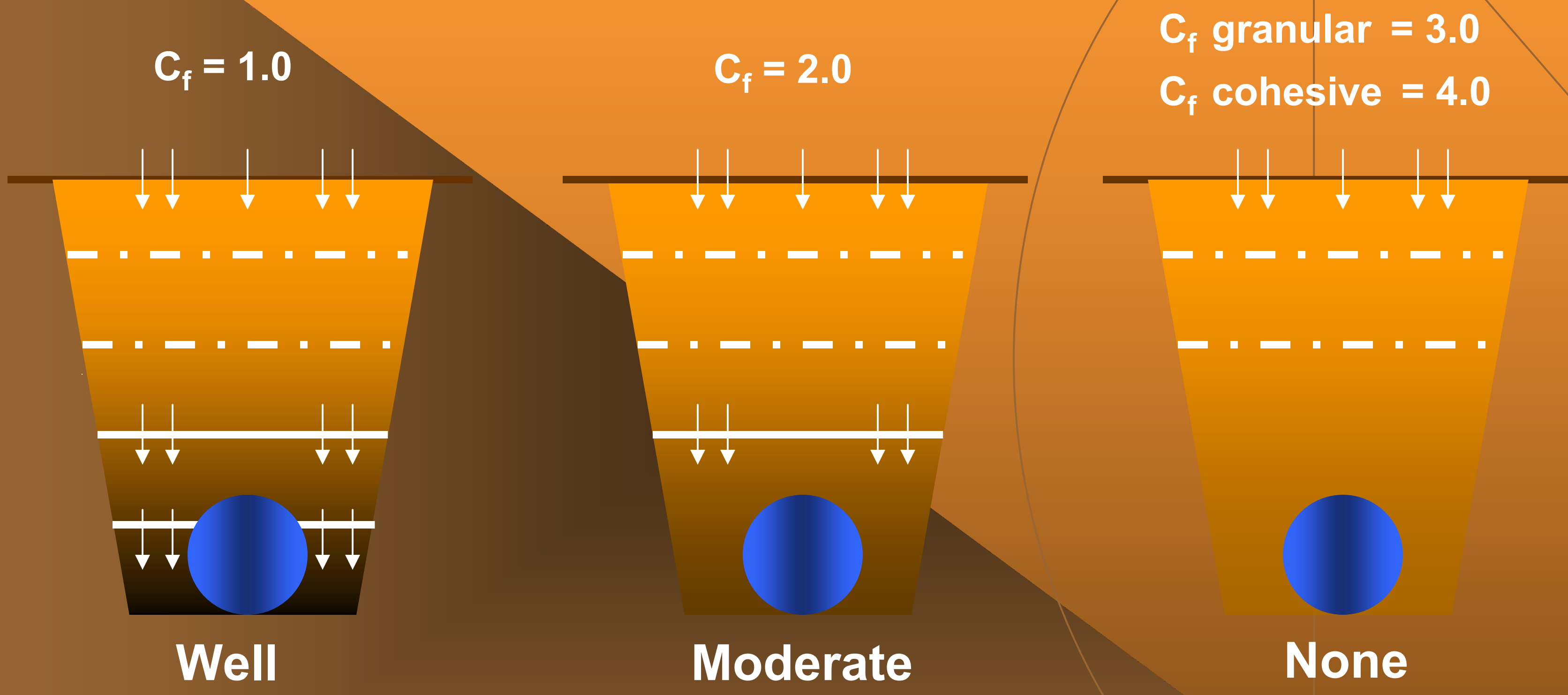


The average deflections immediately after installation are represented by the lower boundary of each area, and the maximum values by the upper boundaries.

FJA



Installation practices used in the project



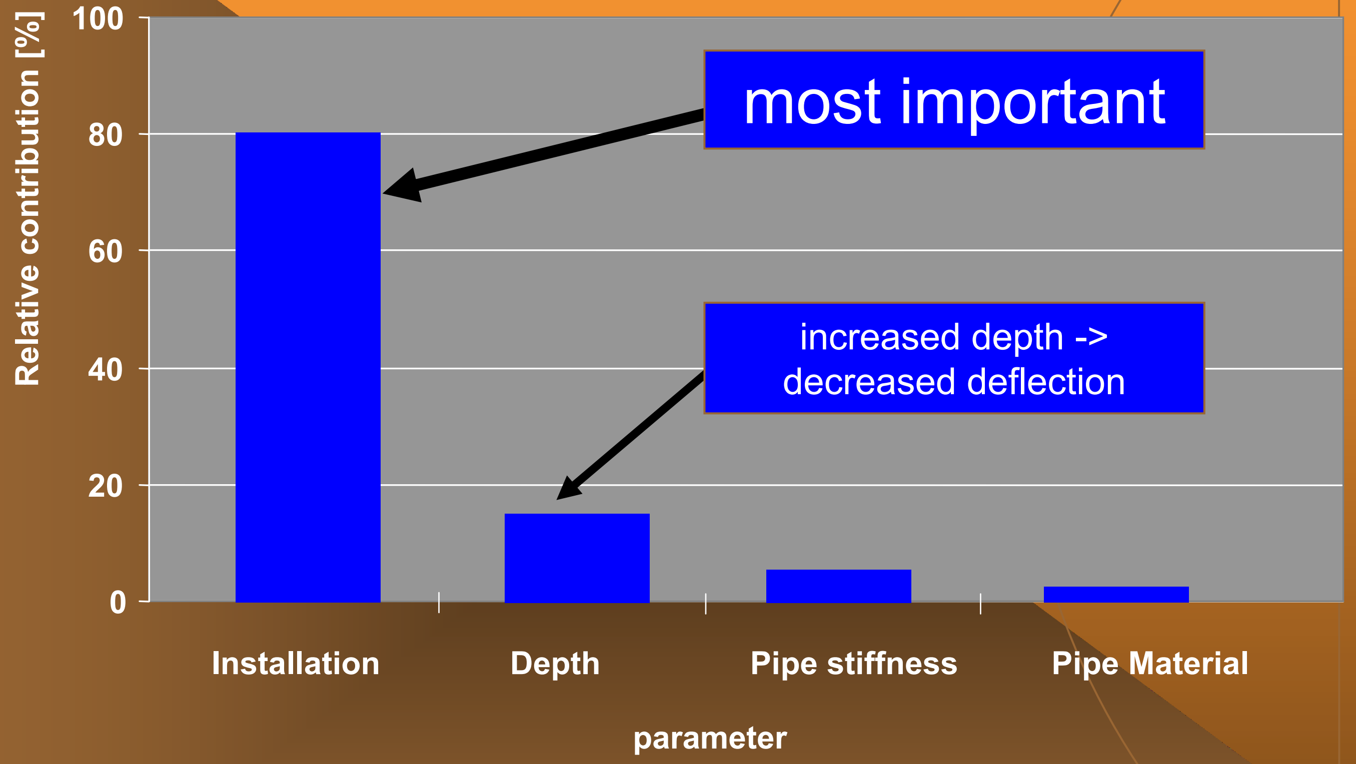
The paradox

"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".

Effect of parameters on deflection



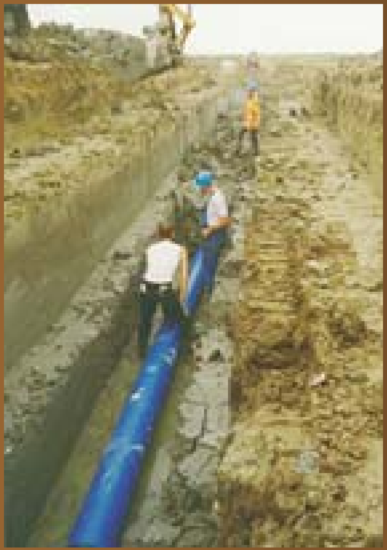
Conclusions

- Depth and traffic load have no effect on the final deflection.
- For “Well” to “None” type of installation:
  - pipe stiffness not important
  - creep ratio / material not important
  - deflections stay very low
  - limit state conditions are not likely to occur

Key property : Strainability !

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

Impressions



TEPPFA
The European Plastics
Pipe and Fitting Association

Plastics
Imagine the potential