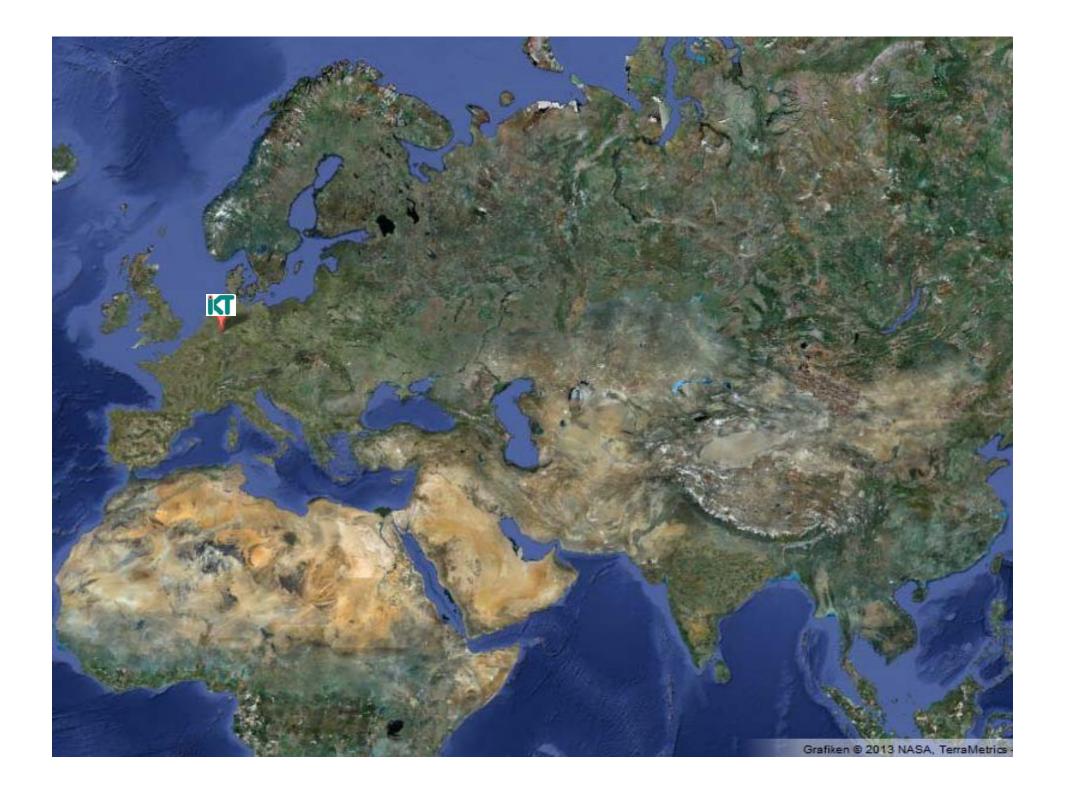


Collaborative research on underground infrastructure

Bert Bosseler

Prof. Dr.-Ing. habil., M.ASCE Scientific Director IKT – Insitute for Underground Infrastructure Gelsenkirchen (Germany) / Arnhem (NL)



IKT – Institute for Underground Infrastructure





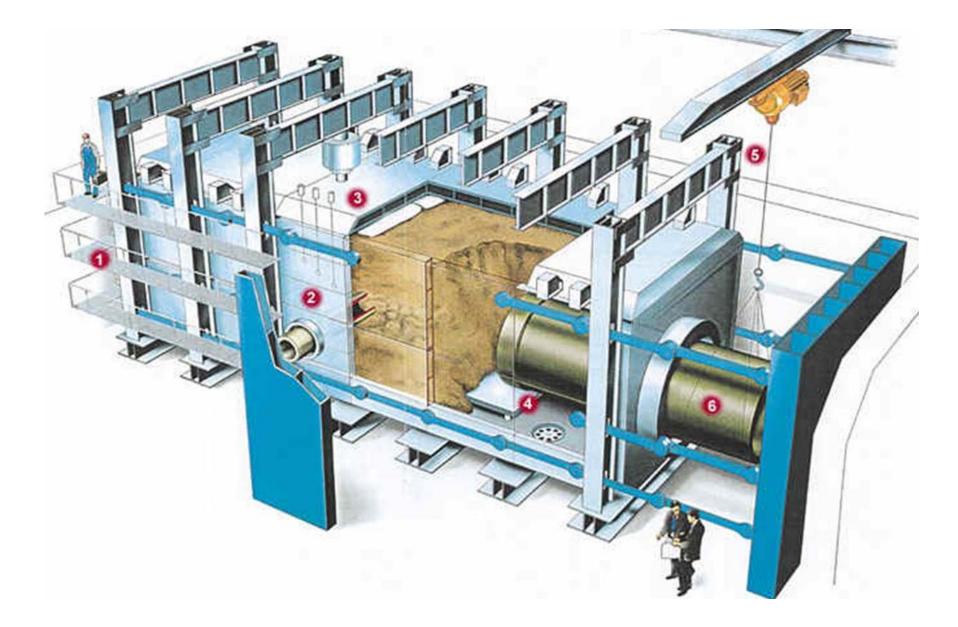
IKT – Facilities





IKT full scale experimental facility







IKT research: In depth studies of specific problems experienced by sewer network owners, identification of causes and potential solutions => quality factors

IKT Compare: Review of the products/systems/installers available in the market; design of a 1:1 scale test rig with relevant scenarios; installation on the rig and in situ by suppliers/contractors **=> performance ranking**

Quality Assurance: Guidelines for tendering requirements and quality assurance => continuous quality testing on site

Training, networking experience and more ...

IKT's collaborative research focus: IKT Compare



• IKT Compare Concept and experience

• Example

Repair of lateral connections

Consequences

for network owners and product suppliers

IKT Compare concept



Goal:

- To create market transparency
- To lower investment risks

Funding:

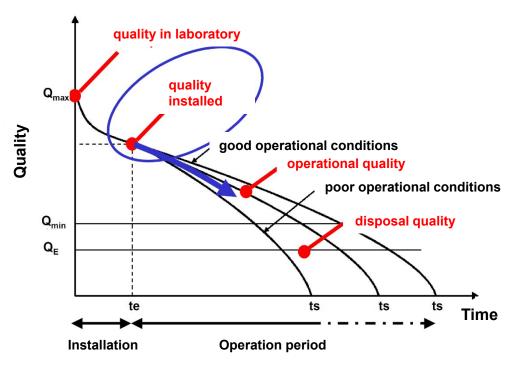
- Group of network owners (steering committee)
- State agencies (sewage fee refund)
- per project (2 years): 0.5m to 2m €

Decisions by network owners:

- Products, methods, suppliers
- Testing goals and concepts
- Evaluation / grading of test results

Market consequences:

- Test results are published
- Quality assurance / product improvement



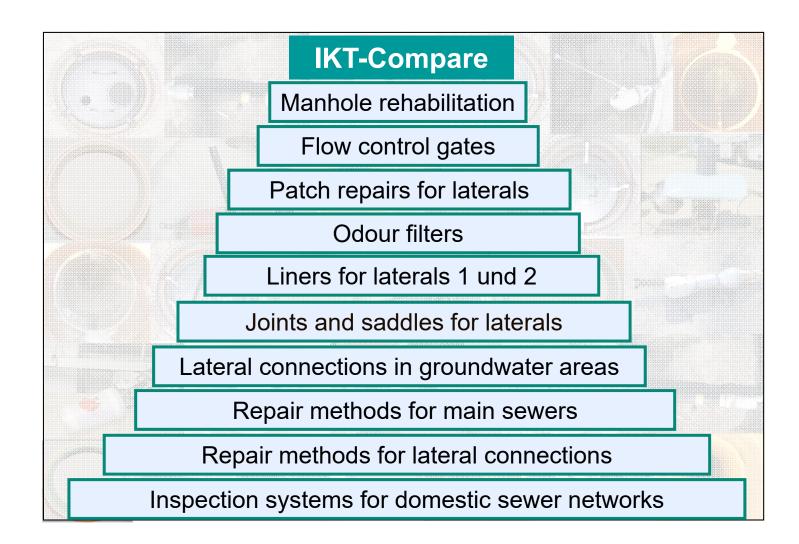
IKT Compare – Tested products





IKT Compare – Reports published





IKT – Compare, publication of results (German, English, Dutch, ...)

Institute of mouths (very pool = 1.2-1.8 Bufficient = 3.8-4.8 Const = 1.8-2.8 Page = 4.8.45.8 Definitution = 1.8-2.8 Page = 4.8.45.8 Definitution = 2.8.-2.8 Page = 4.8.45.8 Definitution = 2.8.45.8 Definit = 2.8.45.85.8 Definit = 2.8.45.85.



IKT - Institut für Unterirdische Infra	struktur						-ICT											
IKT - Warentest "Drosselorgane" Testaulgabe Simulation eines 25-jährigen Le																		
Drosselorgane	HydroSlide Automatik regier Giehimatic	APA-SSD 200 Typ II	Waage-Drossel Typ II	Turbo-A drossel TUR	Wirbel- Alpheus-Abflus: \$3,3 DN 200 begrenzer Typ Auto	natik Str	ahi-Drossel Typ I											
lotieler	Steinhardt GmbH Wasserlechnik	APA Absesserbedrok GmbH	tigs-Umweitschutzenlagen GrebH	Dr. H. Brond	Puid-Technik BIODEST AG	bgu	Omeetachutzenlagen Gwert											
KT - Prüfurteil*	GUT 2,1	BEFRIEDIGEND 3,3	BEFRIEDIGEND 3,3	BEFRIED	GEND 3,5 MANGELHAFT !	,0 NIC	HT BEWERTET**											
ystemprüfungen 80	% gut 1,8	befriedigend 3,5	betriedigend 3,5	befriedig	pend 3,5 mangelhaft 5,1		nicht bewertet											
lydraulische Funktionsfähigkeit bei 25 Es 35	% 1,3	1,9	3,4					-										
nit Schmutzwasser. Drossel ungeneinigt: Fall Betrebstauglichkeit II. 40%	1.0	2.0	0,0															
rel Schmutzwasser. Drossel gereinigt Fall ScieNO 8 20%	1.0	2.0	2.5		IKT - Institute for Undergro	ound Infra	structure							separate V				
nit Klanwasser, Drossel geneinigt, mit Dinstau Fall Betriebstaugiktiteet 1 20%	2.0	1.6	1.5		IKT Compare "Short Liner fo	r House Co	onnections"											
mit Klawasser, Drossel gereinigt.	1.0	1.5	1.0		Test task: Rehabilitation of dat													
Fall SladVO F 10% vdraulische Funktionsfähigkeit bei 10 Ks 31		8.4	3,6		and subsequent eva	luation against	t groundwater pressure	r, operational loadings a	nd backed-up water									
est Schmutzwasser, Drossel ungeweinigt	2.0	6.0	6.0		Supplier		Twinbord Liner	Trelleborg Pipe Seals	Bodenbender	BKP Berolina	Cosetic Engineering	MC-Bauchemie	alocit Chemie	8.S.T.				
Fall Detrobatauglichket I 42% mit Schmutzweiser, Droseil gewingt	1.0	6.0	1.0					and the second										
Fall SueVO 8 20% ret Klavesser, Drussel gereinigt, mit Einstau					System		ToL-Vertehren	epros DrainPacker	Paint-Liner-System	Berolina Repair Syst	err TopHel System	Kenudur LM-Uner	Aloot Shert Liner	Spot Repair System				
	2.5	6.0	2.5		Tradition .		JT etaktownik Gangaire	Testadory Pipe Sean	Bodarbandar.	Cassalar Kanar Tach	Cosmic Engineering	Satisfungstectiviti Domma	KANAL PLUS	167				
ret Klavassar, Drosai generigt Fall SueVO F 10%	2,2	2,0	2.0			_	VERY GOOD	VERY GOOD	GOOD	G000	GOOD	GOOD	SATISFACTOR					
Antegesicherheit" 20		4,9	4.0		IKT – Test Result*		1.2	1.4	1.7	2.5	2.5	2.5	2.7	2.9				
Zustand nach Nutzungsende* 51	s 12	2,0	2,0		System tests	66 %	very good 1.2	very pood 1.5	good 1.8									
Qualitätssicherung ⁸ 11	% behiedigend 3,5	gut 2,0	gut 2,5	befries	1. Water tightness	60.%	1.0	1.0	2.1									100
Drossel-Kanndaten / Gerantiebereich angegeben ja		+/+	+/+		_ under proundwater pressure and		1.0	1.0	13		IKT – Instituut voor	nderarondse Inf	rastructuur					
Betriebe-, Wartunge- s Einbeuanleitung 1 Betriebsanweisungen s Gefähltungsbeurteilungen 1	n +		:			10%	1.0	1.0	25			-	-					
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Eigenberweitung / Prendiberweitung je	en/+	+/+	-1+		 under heavy rain conditions - inditration 8 		**	4.0					gewijze schade".		vorm van een boorgat met een diam diameter op een oppervlak van 20 cr		and an and an and an and	
	n .		Contraction & Changer		(backed-up water in pipe, groundwater pressure changes) ⁴		Saras.				-	onderpro	ndvoorbereiding.			n i 20 cm met sindade van ponsg	ewitre Service of Ge	
	Tu kare Autospater (v)	Kern AufZigkeinn (r)	kare Autilighter (r)	Table Au		60%	1.0	10	2.8			 5x 'ondic 	hte ringvoeg":	ringvoegen met eik 41	loorgaten 6 mm diameter.			
Vorlandernationen (nicht Teil der Benotung) Vorlandersein beweglicher Teile / Bedarf an Fremdenerg	e ja/nen	prinen.	ja/nen	0.00	Test Setup 3 Z. Operational reliability	20%	1.0	2.4	10		nbieder		1.000	Remmers	SEKISUI SPR	Remmers	MC-Bauchemie Müller GmbH	FSB Bautechnik GmbH
Autostunguat	Parts .	habtockan	habrocken	14571		00%	2.5	2.0	18				Bau	stofflechnik GmbH	Germany GmbH	Baustofftechnik GmbH	& Co. KG	
Gewicht (kg) / Alzmessungen (m)	170/0,7 + 0,9 × 1,8	430/17x09x14	170/18×0.8×1.0	0,3 x		30 % 20 %	17	2.6	3.0		Systeem			Betolix R4 SR	GVK - achesiel	GVK - advessel	Ombran MHP	Spectrasheld
Spätetsä, vorhanden i Clauer (s) / Abflusspäte (in) Anta-Auslie unhanden / Clauer (s) / Abflusspätes (iv)	nen/+l= nen/+l=	(4) (30) (13 (4) (40) (13	main1+1+ main7+1+	10/	CCTV inspection* 3. Structural stability	20 %	1.0	2.1	1.0				244	Bautersstutzechnik für				the second second
Zetauheand Er Ein-/ Um-/ Austrau (min)	85 / 180 / 25	95/340/20	65/8/20	100	Short liner stability	70 %	1.0	2.5	1.0		Seinsteleent door			onh- und Talbau GmbH	HMS Pipe Technologies GmbH	KMS Ppe Technologies SmbH	Heliaus #5 Kanahaniasungan SmbH	85G Beschuttungs Gmbri
Hoster: Anschaffung (Montage / Umbau (shne Medit) §) Notest-enchrung auf Sera ungerundere Werk "Notesta		P 550 / 1.450 / 1.450	7.400 r milusive r k.A.	8,819		30 %	1.0	1.0	1.0		KT - testoordeel"		BE	REDIGEND (2.9)	BEVREDIGEND (3.5)	BEVREDIGEND (3,5)	VOLDOENDE (3,6)	NIET BEOORDEELBAAR" wegens systeemtalen
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a Deserving unit Foreinstellingen und Konstantinstelligt wirden Bewertung unit Foreingeneden, unit Heisetse nachgewiesen, Dieses Bestehl aus Neue Frideelunge Metaspererung und Sates	* right raingevenen			 Beth 	Pressure test after excavation, number of: water tight / leaking / not asse	adde	8/0/0	6/0/2*	3/1/4*		Kintlanenke grandwakerdisk, 17.5		4.7)	17	4.9	43	2.8	Net textribellaar
Revenungezmüsser der Pickegebrisse Getr Gul • 1,5- 1,1 Gul		nd = 1.6 - 6.1. Margamati = 6.6 - 8.5. Urgerig	end • 18 - 12	Anpin	Adhesive tensile strength (2 / minimum (N	imm*)	31/29	20/17	not assessable?		Langdurende grundwatendruk, 67 Skaagwermologen (20%)	a. aanatant bij 5 m (20%)		1.8		43	3.3	Nat bestriaethar
				 Profe Drose 	Initial inspection / substrate preparation /	leaning	yes / no / yes*	yes / milling / yes*	yes/no/yes ^{re}	yes/s	kobuuntheid ¹ (20%)				u u	u		u u
WOR - IT Drawnger and investigation in the	10,763,818			2.74	Days on site / Number of staff Time required for preliminary work and in	failution (ca.)	2 days / 3 persons 20 min / 14 h	3 days / 3 persons 165 min / 24 h	3 days / 2 persons 15 min / 25 h		egen purtiquelijte petretan tij de mdruk bij opleveringe (15%)			1.000		10	1000	
opsian cere (a. 42.2/18					Costs excl. VAT (ca.)		-"EUR	1.900 EUR	3.600 EUR		ndruk bij opteveringe (15%) Seschermende werking ^e (5			2,8	17	3.7	3,3	Net becordeelbaar
					· Only calculations on the basis of unsurveint values						Gwaliteitsborging* (15%)			bevredigend (3.5)	onvoldoende (6.0)	otwoldoende (6.8)	zeer goed (1.0)	goed (2.5)
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					 South Property provident with the 1- when the training Descention on the sector of video impediates to the sector video when video accurate accurate present and video after 4 Descention offenite, menual of properties, hences churse 	Dill appear claim	an Opvenment's approvel bedgi.				echnische merkbladen (10% Scholinges (20%): scholinge scholingsaanbod van fabrika	n van renovatiebedrijf (
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an and water 12-13. Senter 13-13. Receiver 1-23-23. Values are 13-23. Other most + 23-13. Output - 14-13

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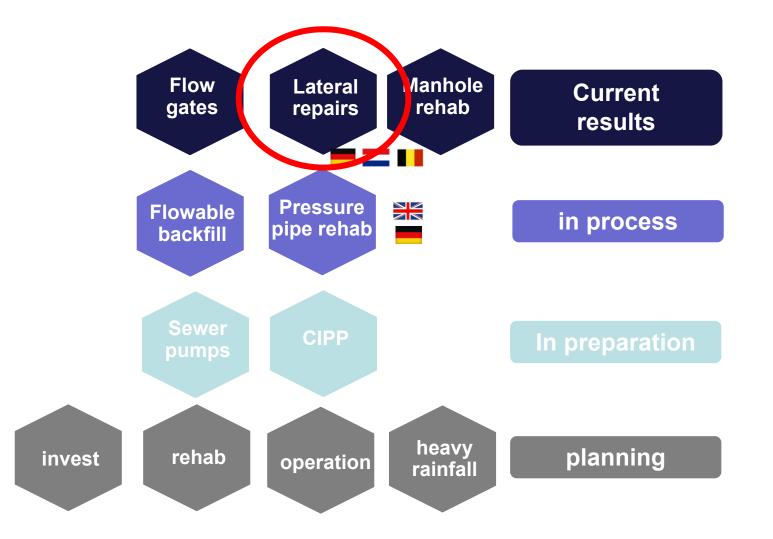
Nar becories



- Quality factors:
 Men / Machines / Methods / Materials
- Quality: Robustness against application errors! (bore holes, surface preparation, mixing and processing, ...)
- Steering committee: project experience is more than just a table of results (product selection, performance criteria, in situ experience, ...)
- Market reaction discloses product capabilites and limits (geometries, damage scenarios, ground water, ...)
- Reactions of suppliers: large range ...

IKT-Compare, current examples





IKT's collaborative research focus: IKT Compare



• IKT Compare Concept and experience

• Example

Repair of lateral connections

Consequences

for network owners and product suppliers

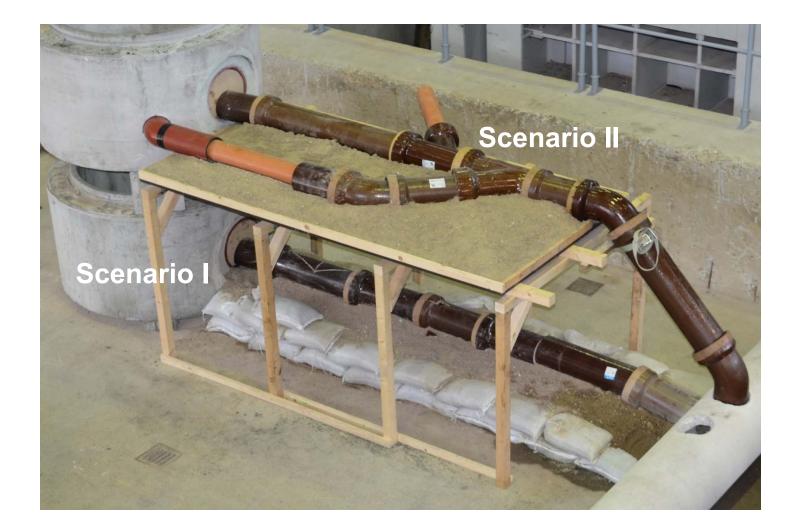
Testing: damage scenario model for part liners





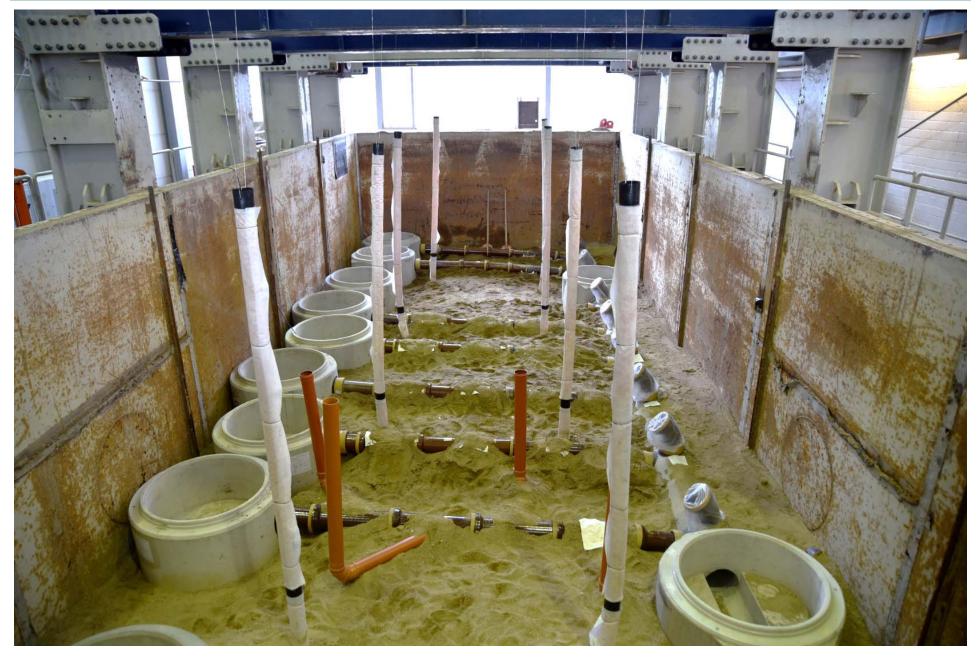
Testing: damage scenario model for part liners





Experimental set-up





Experimental set-up





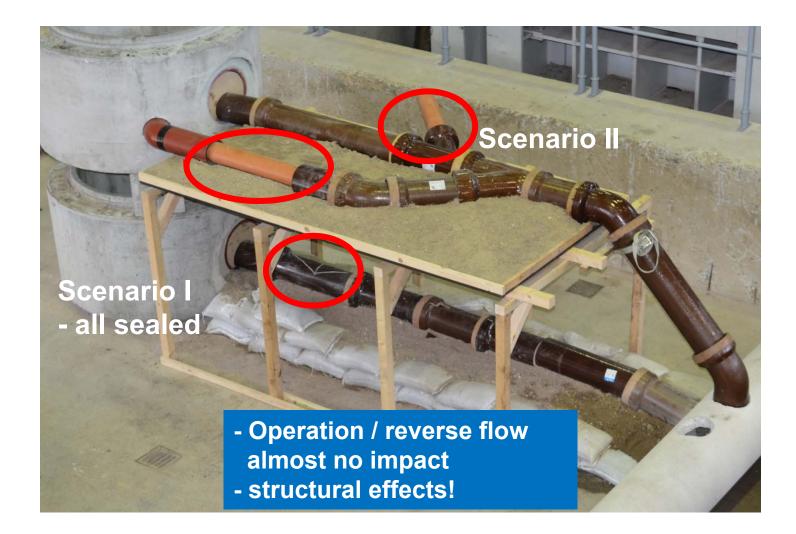
Experimental set-up



Life cycle simulation: - HP cleaning (60 / 80 bar) - external water pressure (to 2 m) - changing ground water level - reverse flow / pressure tests

Test results, example









IKT - Institute for Underground Infrastructure

IKT Compare "Short Liner for House Connections"

Test task: Rehabilitation of damaged house connections

and subsequent evaluation against groundwater pressure, operational loadings and backed-up water

Supplier		Twinbond Liner	Trelleborg Pipe Seals	Bodenbender	BKP Berolina	Cosmic Engineering	MC-Bauchemie	alocit Chemie	I.S.T.	
System	TbL-Verfahren	epros DrainPacker	Point-Liner-System	Berolina Repair System	TopHat System	Konudur LM-Liner	Alocit Short Liner KANAL PLUS SATISFACTORY 2.7	Spot Repair System I.S.T. SATISFACTORY 2.9		
Installer	JT-elektronik GmbH	Trelleborg Pipe Seals	Bodenbender	Casseler-Kanal-Technik	Cosmic Engineering	Sanierungstechnik Dommel				
IKT – Test Result*	VERY GOOD 1.2	VERY GOOD 1.4	GOOD 1.7	GOOD 2.5	GOOD 2.5	GOOD 2.5				
System tests	85 %	very good 1.2	very good 1.5	good 1.9	good 2.7	satisfactory 2.6	satisfactory 2.8	satisfactory 3.0	satisfactory 3.2	
1. Water tightness	60 %	1.0	1.0	2.1	3.1	3.2	3.1	3.5	3.6	
under groundwater pressure and operating loads ¹ - Infiltration I 70 %		1.0	1.0	2.3	3.5	3.8	3.0	3.8	3.5	
Test Setup I 50 %		1.0	1.0	2.5	1.0	3.0	1.0	2.0	1.0	
Test Setup II 50 %		1.0	1.0	2.0	6.0	4.5	5.0	5.5	6.0	
under heavy rain conditions - Infiltration II (backed-up water in pipe, groundwater pressure changes) ² 30 %		1.0	1.0	1.8	2.3	1.8	3.3	3.0	3.8	
Test Setup I 50 %		1.0	1.0	2.5	3.0	2.0	1.5	1.0	1.5	
Test Setup II 50 %		1.0	1.0	1.0	1.5	1.5	5.0	5.0	6.0	
2. Operational reliability	20 %	2.2	2.4	2.1	1.9	2.5	2.1	1.9	2.1	
Hydraulic performance ³ 50 %		2.5	2.6	1.8	2.0	2.6	1.9	2.1	2.3	
Cross-section reduction 30 %		1.7	2.6	3.0	2.0	2.4	2.5	1.6	2.1	
CCTV inspection ³ 20 %		2.3	1.9	1.6	1.7	2.1	1.8	1.9	1.7	
3. Structural stability	20 %	1.0	2.1	1.0	2.3	1.0	2.6	2.6	3.2	
Short liner stability 70 %		1.0	2.5	1.0	1.5	1.0	2.0	2.0	2.0	
Prevention of soil penetration 30 %		1.0	1.0	1.0	4.0	1.0	4.0	4.0	6.0	
Quality assurance ⁴ 15 %		very good 1.0	very good 1.0	very good 1.0	very good 1.0	gut 2.0 no DIBt approval	very good 1.0	very good 1.0	very good 1.0	
Additional information (not graded)										
Pressure test after excavation, number of: water tight / leaking / not assessable		8/0/0	6 / 0 / 25	3 / 1 / 45	7/1/0	0 / 0 / 86	6 / 1 / 1 ⁵	2 / 1 / 55	5 / 1 / 2 ⁵	
Adhesive tensile strength Ø / minimum (N/mm ²)		3.1 / 2.9	2.0 / 1.7	not assessable7	1.9 / 0.8	not assessable ⁸	0.5 / 0.3	not assessable7	3.2 / 2.8	
Initial inspection / substrate preparation / cleanir	ng	yes / no / yes ⁹	yes / milling / yes ⁹	yes / no / yes ¹⁰	yes / roughening / yes ¹⁰	yes / roughening / yes ⁹	yes / milling / yes	yes / no / yes ¹⁰	yes / milling / yes ⁹	
Days on site / Number of staff		2 days / 3 persons	3 days / 3 persons	3 days / 2 persons	2 days / 2 persons	2 days / 2 persons	3 days / 2 persons	3 days / 2 persons	3 days / 2 persons	
Time required for preliminary work and installation	on (ca.)	20 min / 14 h	165 min / 24 h	15 min / 25 h	25 min / 13 h	330 min / 10 h	200 min / 29 h	10 min / 10 h	300 min / 23 h	
Costs excl. VAT (ca.)		- " EUR	1.900 EUR	3.600 EUR	80012 EUR	-11 EUR	3.000 EUR	6.500 EUR	4.700 EUR	
Grade calculation is on the basis of unrounded values 1. External water pressure load 85 days (external water pressure T. 2. Seven changing groundwater loads and 14 water backing-up even 3. Evaluation on the basis of video inspections by the steering comm 4. Water 1. Seven instandard pressure and 4% she THD clear 4. Evaluation on the instant of procedures, training ourses, DIEI at 1. The steering standard procedures, training ourses, DIEI at 1. Not assessable, as no pressure build-up may possible due to une 7. Test of adhesive training strength cannot be carried out due to the 2. Test of adhesive training the strength cannot be carried out due to the 2. Cleaning of notes pipe before removalion with high pressure jetting.	nts. hittee member hing max. pres upproval (Gern anomalies obs xpected dama cracks in the h system, as a f	s (weighting: 20% directly after refurt sure). Ian Government's approval body), erved. ge to the host pipe. ost pipe. Ull-surface bond between the old pip				•	TEST rified clay pipe DN 150: Pattern of cracks Broken out shard (pipe Offset (radially displace Angular deflection (pipe	burst/collapse) d pipe joint)	ngle)	
ID Clearing host pipe before renvation with hose pipe using domestic water supply pressure. 1 Ho coals charged. 2 Installation costs without material, as material costs were borne by the system provider BKP Berolina. Tanding of results.						Test Setup II: Pipe with a branch into two pipes (vitrified clay pipe, PVC, cast iron – DN100/125/150):				

Very good	= 1.0 - 1.5	Sufficient	= 3.6 - 4.5
Good	= 1.6 - 2.5	Poor	= 4.6 - 5.0
Satisfactory	= 2.6 - 3.5	Insufficient	= 5.6 - 6.5

- - Damaged change of material joint
 - Nominal diameter and material change (2x)
 - Broken out shard (pipe burst / collapse) in a 45° bend

IKT's collaborative research focus: IKT Compare



• IKT Compare Concept and experience

• Example

Repair of lateral connections

Consequences

for network owners and product suppliers



For network owners:

- Reducing investment risks, what do I get for my money?
- Market overview, product performance
- QA/QC recomendation, tender documents
- Competion on a higher quality level

And for IKT?

For suppliers:

- Chance for performance prove / test winner
- Market pressure / definition of customer requirements
- Improvement potential / additional tests

IKT – Institute for Underground Infrastructure

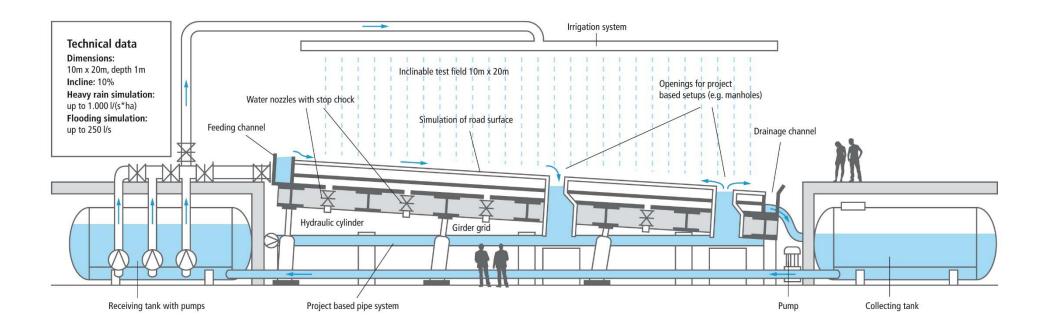




EFRE-Investment "research infrastructures": IKT – testing facilities: heavy rainfalls and new products and materials



Join in!



IKT – UK and International





lain Naismith PhD Project Manager, UK and International Watlington Office, UK T: +44 (0) 1491 712707 M: +44 (0) 7983 605219 E: naismith@ikt.institute

Developing research and improving QA with the UK and Ireland's 13 Water and Sewerage Companies and collaborations with UK research organisations and universities

