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# **Quality Control Factors of CIPP Construction Management for Water Main Rehabilitation**

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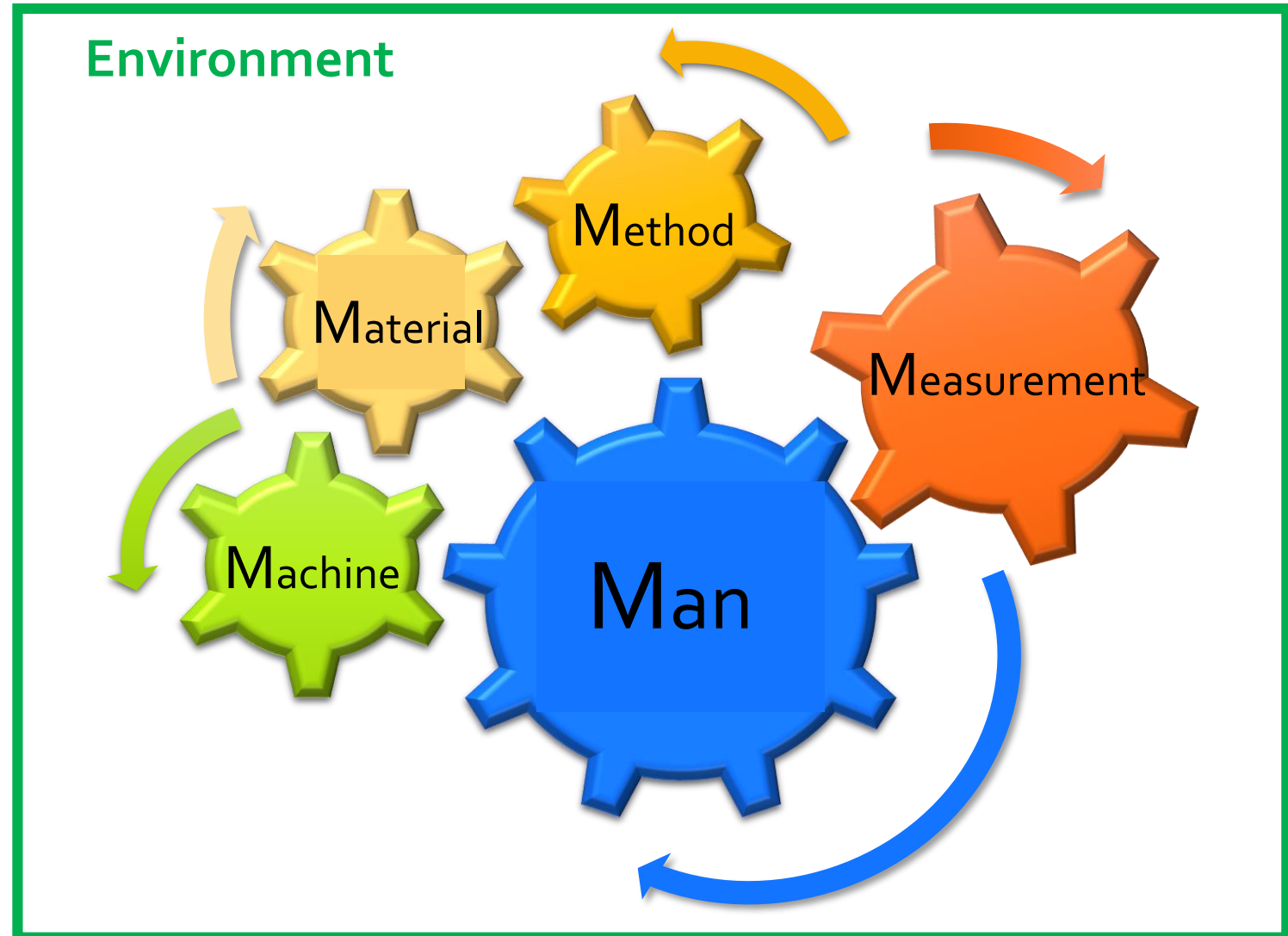
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# INTRODUCTION

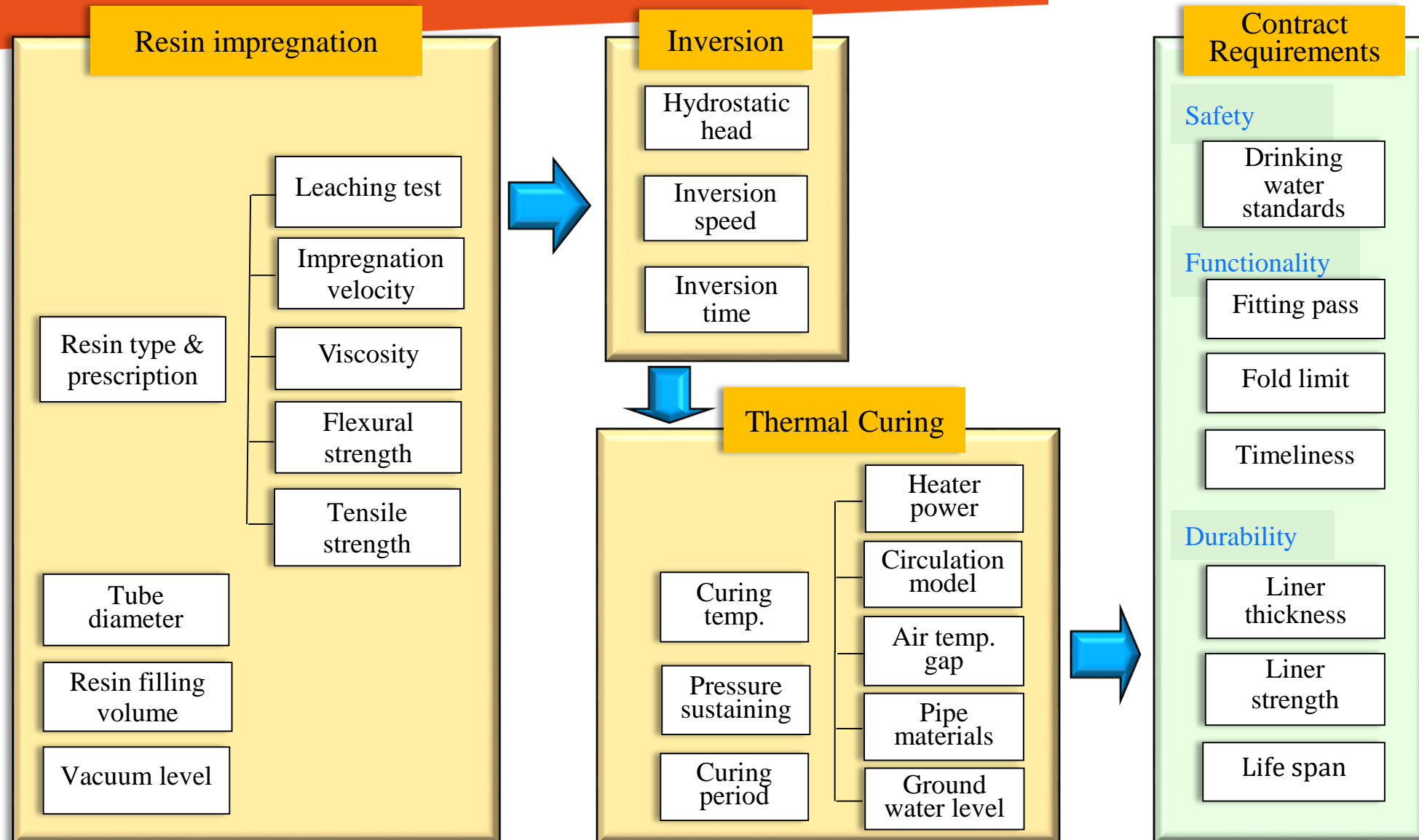
## 5 M 1 E Management Elements



# CIPP of Water Transmission in Taipei



# Quality Management Framework

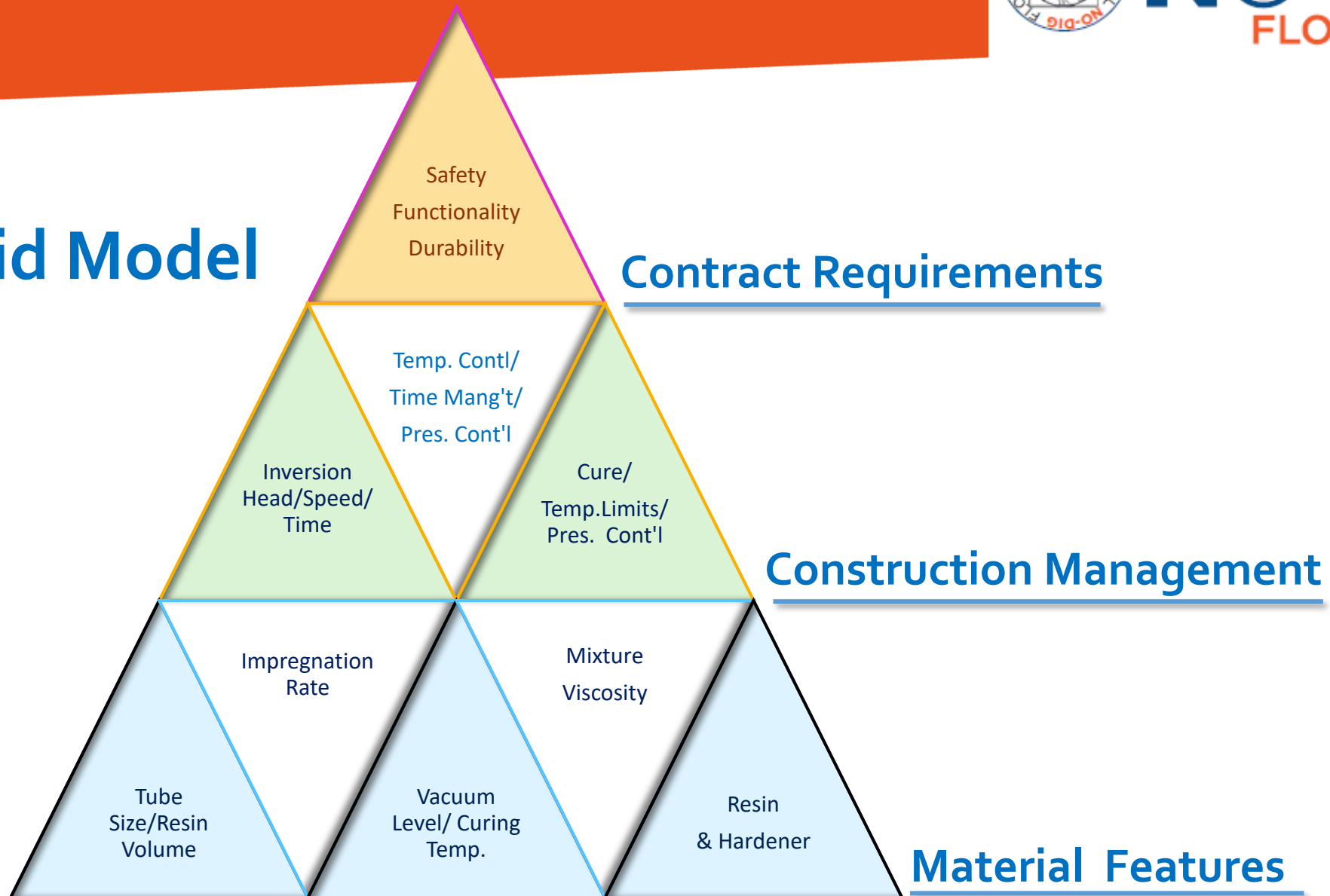


# Superposition Effect of CIPP Quality Factors



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## Pyramid Model



# Major Quality Control Factors of CIPP Construction

Operation	Control Factors	Quality Parameters	Operation Required & Standards
Resin Impregnation Operation	Flexible felt size	<ul style="list-style-type: none"> <li>● Length</li> <li>● Axial folds criteria(Diameter oversize)</li> </ul>	<ul style="list-style-type: none"> <li>● Sampling bare tube at terminal</li> <li>● Elastic coefficient of the lining tube (tensile strength)</li> </ul>
	Prescription of resin & hardener	<ul style="list-style-type: none"> <li>● Leaching test</li> <li>● Compatibility tests (viscosity, permeability, impregnation rate, reaction rate)</li> <li>● Flexural strength test</li> <li>● Tensile strength test</li> <li>● Gravity Deformation Rate of Bare Tube</li> </ul>	<ul style="list-style-type: none"> <li>● Drinking water standards</li> <li>● Porosity of woven fabric and glass fiber layer</li> <li>● Structural strength of bare tube</li> </ul>
	Volume of resin filled	<ul style="list-style-type: none"> <li>● Thickness</li> </ul>	<ul style="list-style-type: none"> <li>● Cost of resin</li> </ul>
	Vacuum level	<ul style="list-style-type: none"> <li>● Impregnation velocity</li> <li>● Thickness of the cured tube</li> <li>● Structural strength of cured tube</li> </ul>	<ul style="list-style-type: none"> <li>● Viscosity</li> <li>● Structural strength of the cured tube</li> </ul>
Inversion Operation	Inversion hydrostatic head	<ul style="list-style-type: none"> <li>● Inversion driving force</li> </ul>	<ul style="list-style-type: none"> <li>● Features of existing pipe (material ,diameter, length, fitting Types &amp; number)</li> <li>● Limitation of operating space</li> <li>● Viscosity of resin mixture</li> </ul>
	Inversion speed	<ul style="list-style-type: none"> <li>● Design thickness</li> <li>● Pass the bends</li> <li>● Circumferential folds</li> </ul>	<ul style="list-style-type: none"> <li>● Tube feeding capability (forward)</li> <li>● Control cable operations (brake)</li> <li>● Allowable operating Time for inversion</li> </ul>
	Inversion time	<ul style="list-style-type: none"> <li>● Strength of cured tube</li> </ul>	<ul style="list-style-type: none"> <li>● Resin &amp; hardener features</li> </ul>
Curing Operation	Curing temperature	<ul style="list-style-type: none"> <li>● Curing time</li> <li>● Temperature uniformity</li> </ul>	<ul style="list-style-type: none"> <li>● Heater power</li> <li>● Heater and circulation system</li> </ul>
		<ul style="list-style-type: none"> <li>● Deformation of Plastic Layer(water-contacted)</li> </ul>	<ul style="list-style-type: none"> <li>● Upper limit of temperature</li> </ul>
		<ul style="list-style-type: none"> <li>● Total curing time</li> </ul>	<ul style="list-style-type: none"> <li>● Lower limit of temperature</li> </ul>
	Required pressure	<ul style="list-style-type: none"> <li>● Flexible tube tight against existing pipe wall</li> </ul>	<ul style="list-style-type: none"> <li>● Inversion water head</li> </ul>
	Curing time	<ul style="list-style-type: none"> <li>● Strength of the cured tube (hardness test at terminal)</li> </ul>	<ul style="list-style-type: none"> <li>● Textures of existing pipeline, air temperature, underground water level, etc.</li> </ul>

# The Fuxing Project

- DN 1000mm MJP transmission built in 1971
- Total length 812m and depth 4.2m.
- 6 work pits and 5 sections.



# The Xinsheng Project

- DN 800mm CIP pipeline, 1963
- Total length 771m
- Layout 7 work pits and 6 sections.



# The Specifications and Tests of Materials in Contract

- **Water Safety** - Leaching test(Turbidity, Color, Odor, Residual chlorine reduction , TOC, Phenols, Cyanide, Formaldehyde, Styrene etc.
- **Pipe Structure** - Vertical Curvature and inner Pressure tests (bare pipe), Thickness, Hardness, Tensile strength and Flexural strength tests (slide sample)
- **Construction Required** - Compatibility tests(viscosity, permeability, impregnation rate, reaction rate) and Curing test( room temperature & heating )



Leaching test



inner Pressure test  
( $\leq$  ID 4% under 0.3 Mpa)



impregnation rate

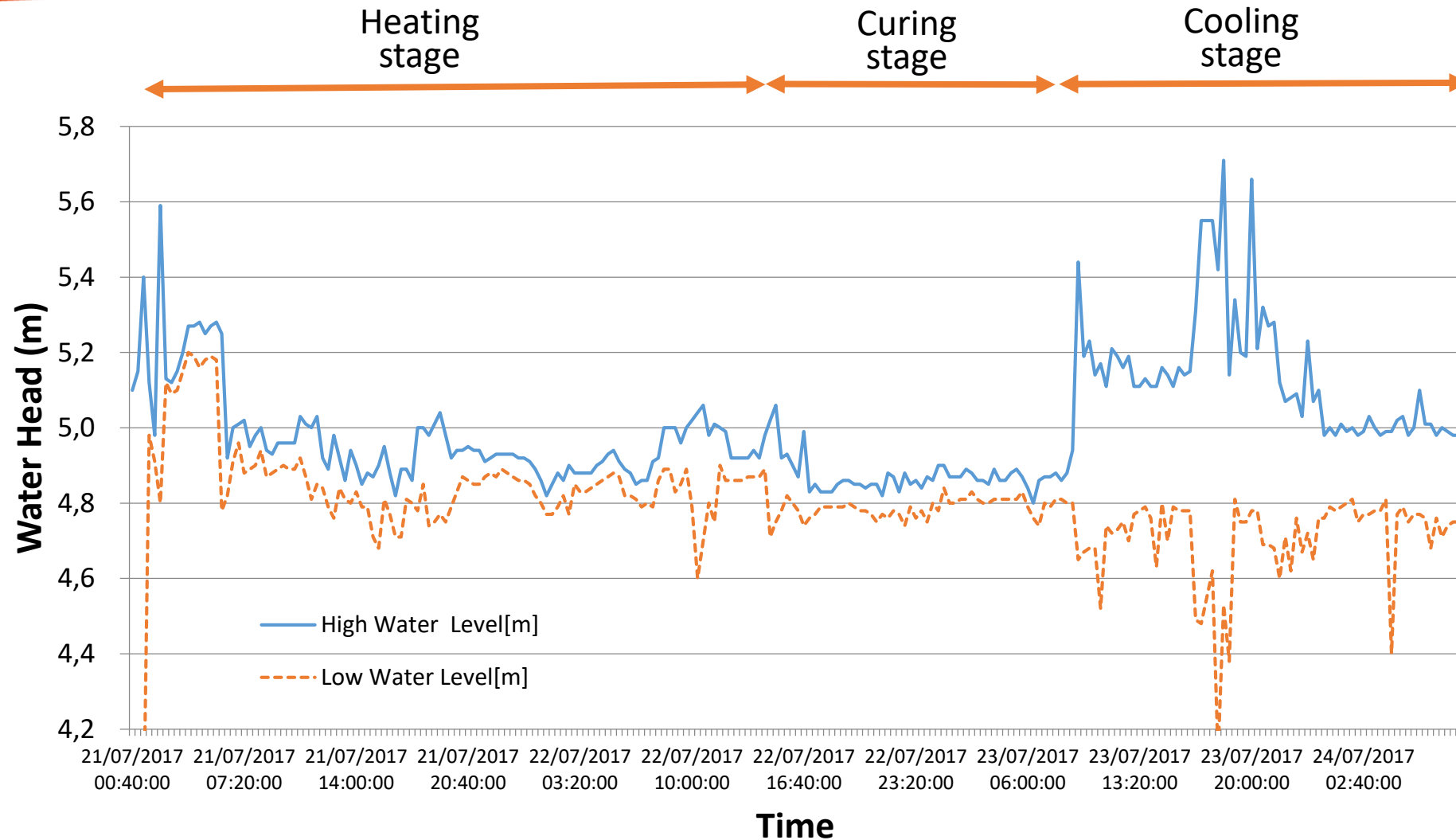


reaction rate

# Control of Inversion Water Level in the Fuxing Project



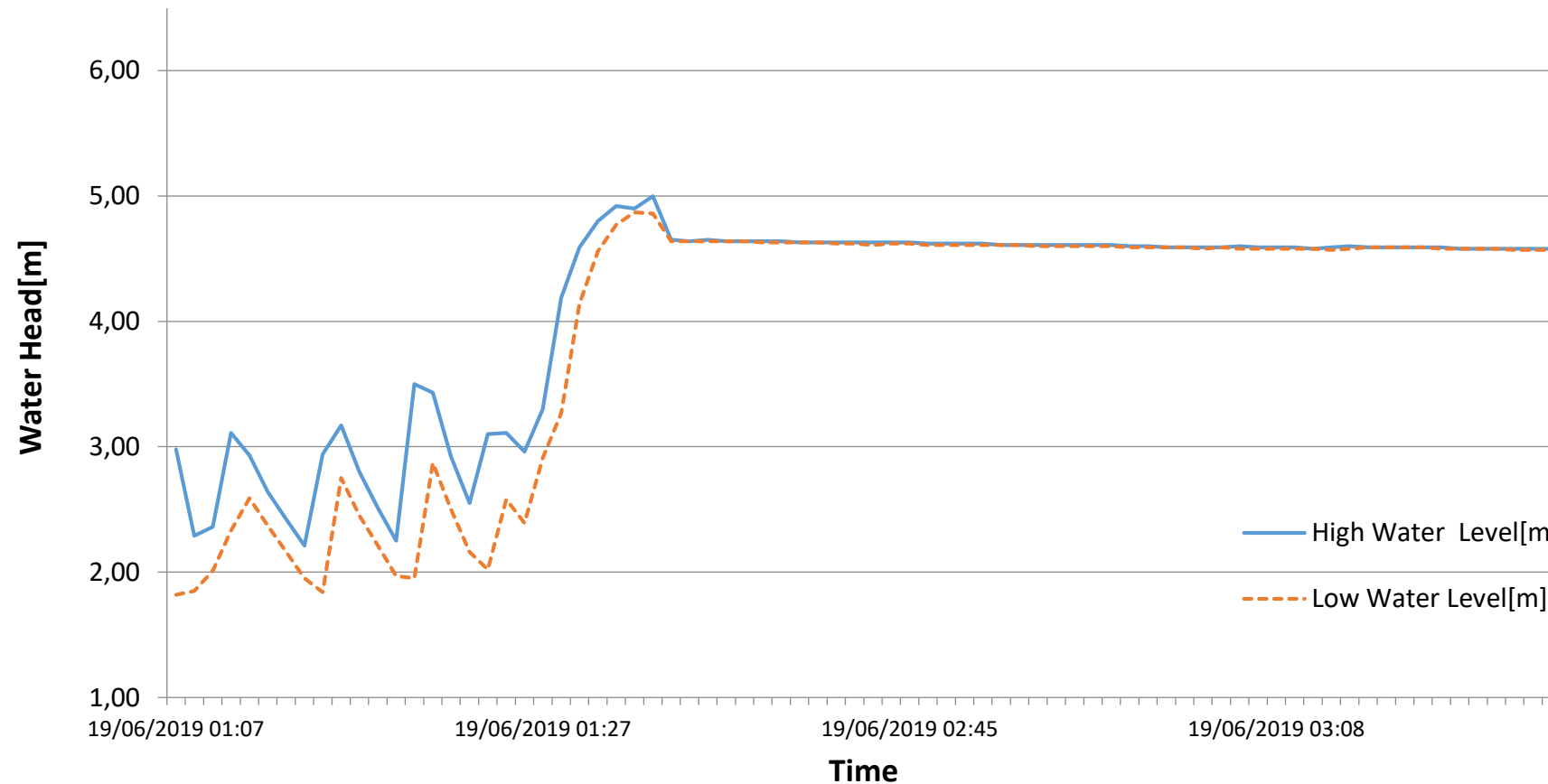
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# Inversion Speed Controlled by Water Head in the Xinsheng Project



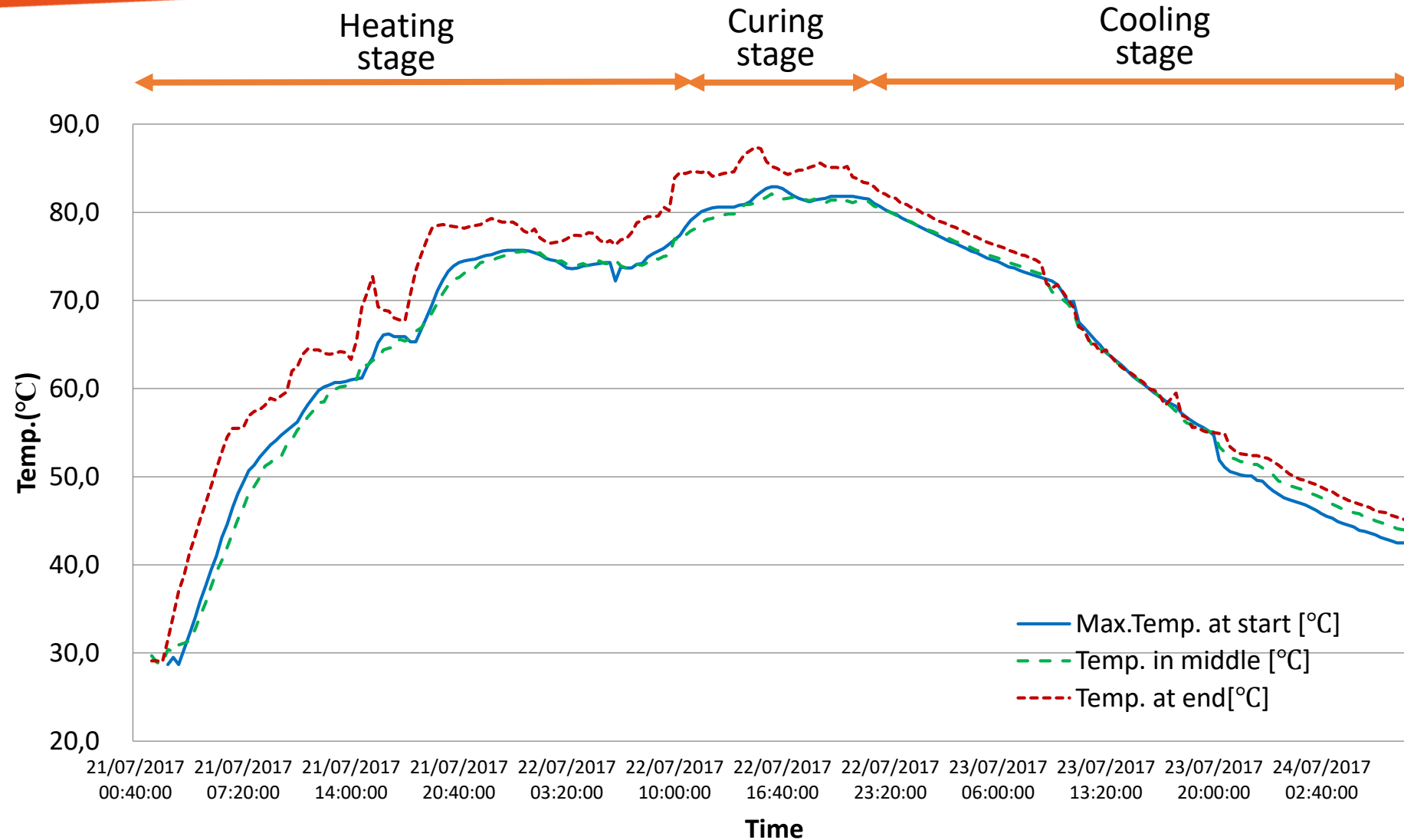
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# Thermal Curing Curve of the Fuxing Project



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# CONCLUSION



1. The quality management framework of CIPP projects consist of resin impregnation, tube inversion, and lining curing, which shall be managed as a whole in construction.
2. The key operational factors of quality control are mutually influenced by each other and have a superposition effect. The features of tube materials are regarded as highly relative factors with operations of construction on-site.
3. It is recommended that civil engineers manage CIPP projects in a full process perspective and comprehend the characteristics of resin and flexible felts in cases, which will ensure the lifespan of cured pipeline.

Better Water Better Life



# Digital Thermocouple Sensors and Monitoring Panel Record

Start Point



End Point

