The Concept of Value Engineering in Application of GRP Pipes for Water and Sewage Transmission

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FARASSAN Manufacturing and Industrial Company
FARATEC Technology Center
Farassan Manufacturing and Industrial Company

- Established in 1986 in Iran as an FRP towers and blade manufacturer. The company has been producing pipes for the global market since 1993.
- EPCF project contractor in water and sewerage

- Largest manufacturer of GRP, GRE and GRVE pipes and fittings in Iran
  - Has executed more than 7000km in water and sewage transport projects, 1600km in O&G industry
  - Design, manufacture, transport and install GRP pipes
  - Pipes produced under brand name “Faratec” and exported to 17 countries in Asia, Europe and Africa
  - Five plants in Iran, One plant in Turkey, JV plant in Algeria
    - Nine production lines, each line having a capacity of ~250km/year up to 3000mm in diameter
    - Dedicated plant for GRE pipe fittings, joints, and manholes
    - Dedicated GRP Towers, pressure vessels and Tanks production facility
    - Dedicated steel workshop and GRP pipe machinery manufacturing
  - 1000 employees with over 100 technical staff

- Also produce FRP towers and tanks up to 7.5m in diameters
- Turnkey manufacturing facility designed and installed in South Korea
Polymer Composites

Matrix

Polyester Resin (Isophetalic & Orthophetalic)
Venylester Resin
Expoxy Resin

Fibers

Glass Fiber
Kevlar
Carbon
Silicon Carbide

Glass Reinforced Polymer (GRP)
Superior Flow Characteristics
Applications of GRP Pipes

- **Industrial**
  - Industrial disposal
  - Sea water intake
  - Subsea
  - Fire fighting main
  - Desalination plants
  - Treatment plants

- **Civil**
  - Potable water
  - Surface water
  - Irrigation
  - Sewerage
Specifications

• Diameter (DN): Up to 4000mm (160in)
• Pressure class (PN): Up to 32 bar (464 psi)
• Stiffness (SN): 2500, 5000, 10,000 Pa
Filament Winding Technology
GRP Fittings
GRP Pipe Jointing Systems

Flexible Joints
- Key-Lock Coupling

Cemented Joints
- REKA Coupling
- Bell & Spigot
- Glued Coupling
- Lamination
- Flange
Value Engineering (VE)

- Systematic and structured approach for improving projects, products and process
- VE helps achieve an optimum between function, performance, quality, safety and cost
- The proper balance results in the maximum value for the project
- Value is the reliable performance of functions to meet customer needs at the lowest overall cost

\[
\text{Value} = \frac{\text{Function}}{\text{Cost}}
\]
Value Engineering Process

- **Information gathering**: Defining Objectives & requirements

- **Functional analysis**: Determine important functions or performance characteristics
  - Must haves, like to have, must not haves, prefer not to have

- **Alternative generation**: Determine alternative ways to meet requirements

- **Evaluation**: Assess all alternatives with respect to the defined objectives and costing
Function Analysis for Water or Sewer Transmission Pipelines

We evaluate fifteen different criteria

<table>
<thead>
<tr>
<th>Performance</th>
<th>Design Flexibility</th>
<th>Longevity</th>
<th>Transportation &amp; Cost</th>
</tr>
</thead>
</table>

- Cost of pipes, fittings
- Ease of transportation
- Transportation cost and Time
- Damageability during transportation or installation
GRP Pipe Friction Factor

- Allowable velocity of flow for clean fluid is 6 m/s
- The friction coefficient of GRP pipes remain constant during the pipe’s life

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Hazen Williams Coefficient</th>
<th>Manning Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Steel</td>
<td>125</td>
<td>0.013</td>
</tr>
<tr>
<td>Galvanized Iron</td>
<td>120</td>
<td>0.016</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>125</td>
<td>0.012</td>
</tr>
<tr>
<td>Concrete</td>
<td>110</td>
<td>0.014</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>150</td>
<td>0.009</td>
</tr>
</tbody>
</table>
Balancing the Required Diameter

GRP pipes have lower friction factors hence we can use smaller diameter GRP pipes vs. others, e.g. Carbon Steel (using Hazen Williams equation)

\[ h = \left[ \frac{42.7(Q)}{(C)(D)^{2.63}} \right]^{1.85} \]

ID=500mm  
C=110

ID=450mm  
C=150
Life Time Requirements

• According to ASTM, ISO & AWWA standards GRP pipes should have a safe service life of 50 years

• Long term tests
  • Pressure, bending, corrosion, creep and erosion

• Short term tests
  • Joint qualification, tensile strength, elastic modules–poisson ratio, drinking water tests, fire test
Other Features of GRP Pipes

- Resistance to internal and external corrosion
  - No Requirement for coating and cathodic protection

- Flexible mechanical properties
  - Different mechanical properties may be obtained by altering resin and composite material (Strength up to 700Mpa)

- Resistance to earthquake
  - Special type of jointing systems are designed
## Sample Value Engineering Evaluation Chart

<table>
<thead>
<tr>
<th>No.</th>
<th>Pipe Requirement</th>
<th>Synthetic Material</th>
<th></th>
<th>Metallic Material</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GRP</td>
<td>Score (W)</td>
<td>polyethylene</td>
<td>Score (W)</td>
<td>Steel</td>
<td>Score (W)</td>
<td>Ductile Iron</td>
<td>Score (W)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weight</td>
<td></td>
<td>Weight</td>
<td>C</td>
<td>Weight</td>
<td>C</td>
<td>Weight</td>
<td>C</td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>Distance from pipe production factory to installation site</td>
<td>3.4</td>
<td>1</td>
<td>3.4</td>
<td>2</td>
<td>3.4</td>
<td>3</td>
<td>3.4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>- Pipes friction factor</td>
<td>5.2</td>
<td>4</td>
<td>5.2</td>
<td>3</td>
<td>5.2</td>
<td>2</td>
<td>5.2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>- Potential of damage to pipe during transportations and installation</td>
<td>2.45</td>
<td>2</td>
<td>2.45</td>
<td>2</td>
<td>2.45</td>
<td>4</td>
<td>2.45</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pipe life</td>
<td>12.6</td>
<td>4</td>
<td>12.6</td>
<td>4</td>
<td>12.6</td>
<td>2</td>
<td>12.6</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>Ease of installation and maintenance</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Price of Pipes and Fittings</td>
<td>26</td>
<td>4</td>
<td>26</td>
<td>2</td>
<td>26</td>
<td>3</td>
<td>26</td>
<td>2</td>
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</tr>
<tr>
<td>7</td>
<td>Ability to produce the pipes in various pressure classes</td>
<td>2.15</td>
<td>3</td>
<td>2.15</td>
<td>3</td>
<td>2.15</td>
<td>4</td>
<td>2.15</td>
<td>2</td>
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<tr>
<td>8</td>
<td>Performance against external forces</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
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</tr>
<tr>
<td>9</td>
<td>Ease of transportation</td>
<td>2.75</td>
<td>2</td>
<td>2.75</td>
<td>3</td>
<td>2.75</td>
<td>3</td>
<td>2.75</td>
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<tr>
<td>10</td>
<td>Resistance to internal and external corrosion</td>
<td>12.8</td>
<td>4</td>
<td>12.8</td>
<td>3</td>
<td>12.8</td>
<td>1</td>
<td>12.8</td>
<td>2</td>
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<tr>
<td>11</td>
<td>min. and max. available diameters</td>
<td>1.75</td>
<td>4</td>
<td>1.75</td>
<td>3</td>
<td>1.75</td>
<td>4</td>
<td>1.75</td>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td>12</td>
<td>Non-floatation of pipe in region with high ground water level</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
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<tr>
<td>13</td>
<td>requirement to special backfilling material</td>
<td>4.3</td>
<td>1</td>
<td>4.3</td>
<td>3</td>
<td>4.3</td>
<td>4</td>
<td>4.3</td>
<td>4</td>
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<tr>
<td>14</td>
<td>mechanical properties of pipe</td>
<td>0.9</td>
<td>3</td>
<td>0.9</td>
<td>1</td>
<td>0.9</td>
<td>4</td>
<td>0.9</td>
<td>4</td>
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<tr>
<td>15</td>
<td>resistance to earthquake</td>
<td>2.8</td>
<td>2</td>
<td>2.8</td>
<td>2</td>
<td>2.8</td>
<td>4</td>
<td>2.8</td>
<td>3</td>
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<td></td>
</tr>
<tr>
<td>16</td>
<td>After Sales Services</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<td>2</td>
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<tr>
<td>17</td>
<td>Operation Cost</td>
<td>4.9</td>
<td>4</td>
<td>4.9</td>
<td>3</td>
<td>4.9</td>
<td>1</td>
<td>4.9</td>
<td>2</td>
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</tr>
<tr>
<td>18</td>
<td><strong>Sum</strong></td>
<td><strong>329.85</strong></td>
<td></td>
<td><strong>248.15</strong></td>
<td></td>
<td><strong>269.15</strong></td>
<td></td>
<td><strong>256.8</strong></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Scores:** Excellent (4), Good (3), Fair (2), Poor (1)

The weights are considered according to engineering practices.
South-East Iran Water Transmission Pipeline

- Length: 57km
- Flow requirements: 230km$^3$/day
- Steel pipes were chosen initially
  - Diameter: 1300–2000mm
- Different pressures throughout
  - 6–10bar
- Three pump stations
- Pipejacking under railroad
  - Diameter: 2400mm

- Harsh environmental conditions:
  - High tide fluctuations of more than 2.5m
  - Sludgy conditions
  - High levels of underground water
  - Briny and sandy soil
  - Humidity of 95%
  - Temperatures reaching 60°C
  - Installation at 4.5m below ground
Value Engineering Results

- Initial approach considered steel pipes and shifted to GRP pipes after VE analysis.

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Diameter (mm)</th>
<th>Pipe Price ($)</th>
<th>Coating Price ($)</th>
<th>Valve and Accessories Price ($)</th>
<th>Transportation, Installation and Commissioning Prices ($)</th>
<th>Cathodic Protection Price ($)</th>
<th>Total Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP</td>
<td>1200-1800</td>
<td>8,484,848</td>
<td>-</td>
<td>196,970</td>
<td>3,742,424</td>
<td>-</td>
<td>12,424,242</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>1200-1800</td>
<td>12,664,235</td>
<td>-</td>
<td>196,970</td>
<td>3,754,424</td>
<td>-</td>
<td>16,615,629</td>
</tr>
<tr>
<td>Steel</td>
<td>1300-2000</td>
<td>8,278,158</td>
<td>1,353,380</td>
<td>196,970</td>
<td>7,014,201</td>
<td>289,736</td>
<td>17,132,445</td>
</tr>
</tbody>
</table>

RP pipes resulted in an overall cost savings of 35% compared to
Surface Water Catchment
Tehran Water Surface Collection

• High level of rain in Tehran causes flooding in the south of the city

• Network of 12km collecting water from the city and deliver to Cheetgar lake on the outskirt of the city

• Diameters: 1500-2500

• Required manholes throughout the network
  • Developed GRP manholes specific to the project
Value Engineering Results

- Initial approach considered steel and polyethylene pipes and shifted to GRP pipes.

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Diameter (mm)</th>
<th>Pipe Price ($)</th>
<th>Coating Price ($)</th>
<th>Valve and Accessories Price ($)</th>
<th>Transportation, Installation and Commissioning Prices ($)</th>
<th>Cathodic Protection Price ($)</th>
<th>Total Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP</td>
<td>1500-2500</td>
<td>2,721,612</td>
<td>-</td>
<td>34,291</td>
<td>651,532</td>
<td>-</td>
<td>3,407,435</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>1500-2500</td>
<td>3,495,308</td>
<td>-</td>
<td>34,291</td>
<td>653,532</td>
<td>-</td>
<td>4,183,131</td>
</tr>
<tr>
<td>Steel</td>
<td>1500-2500</td>
<td>2,592,757</td>
<td>461,109</td>
<td>34,291</td>
<td>1,221,128</td>
<td>77,783</td>
<td>4,387,068</td>
</tr>
</tbody>
</table>

RP pipes resulted in an overall cost savings of 24% compared to...
Thank You For Your Attention

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