FABRICATION OF GRP/FRP HUGE STORAGE TANKS

A new proven Technology…..

SATYEN POLYMERS PVT LTD

Presentation by R. Raghavan

TRIBUTE TO GOD

GOD HAS FORETHOUGHT AND DID NOT CREATE FIBERGLASS TREES, LEAVING THIS JOB TO FIBERGLASS AND RESIN INVENTORS.

TRIBUTE TO GRP MANUFACTURERS

GOD CREATED HUMAN BEING AND NATURAL RESOURCES. HOWEVER HE ALLOWED MAN TO CONVERT FIBERGLASS AND BINDER INTO MATERIALS OF HIS CHOICE.

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FABRICATION OF GRP/FRP HUGE STORAGE TANKS

A new proven Technology

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- **Max Fabricating Capacity: 500m^3 up to 10000m^3 volume**
- **Max Fabricating Diameter: 6 meter up to 30 meter**
- **Suggest Fabricating Height: 10 meter up to 15 meter**

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In this paper, I am trying to introduce a new concept to manufacture Large GRP tank fabrication developed by a Taiwanese company M/s Kigent corp. Ltd.

The Kigent Corporation Ltd was established in 1979, devoted to chemical resistant tanks by helical filament-winding process .Since 1989, by the new advanced helical filament winding technology.

Kigent has developed and manufactured these products widely in petrochemical, steel, food and electronic industries and military-use. Providing high strength, best corrosion resistance, good performance composite-products for customer is Kigent's first responsibility.

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They are a professional FRP manufacturer of special chemical tanks and equipments such as pressure vessels, scrubbers, fume stacks. Their products have been widely used in a variety of industries including petrochemical, power generation, electronics, marine, and paper etc.

No-failure incident in Kigent's projects is the greatest accomplishment and honor since 1979. with the successfully developed helical filament-winding machine for field production, this company has produced 500m^3 FRP storage tanks, 6 sets of 8 m dia x 10m H, for 32-37% Hydrochloric acid for Formosa and withstood shake-test from the famous 921 (Richter 7.6 scale) earthquake that happened in 1999 in Taiwan. Kigent now has confidence and capability to produce any larger size of FRP storage tanks.

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With 30 years experience and excellent design, Kigent has developed the on-site Helical Filament Winding technology to produce the huge & high qualified FRP tanks for industrial service.

According to the capacity of Kigent's Helical FW machine, we could fabricate the tank when diameter is up to 30 m and 15 m for height, the volume could be up to 10000m^3.

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During the last 5 years the constitution material- viz metal material cost has group by about 300-500% that had seriously affected the budget of various projects. In order to reduce down the investing cost, Kigent follow ASTM, ASME, NBS, PS 15-69, BS 4994, CNS 11656-K308 standards, and promote steps to manufacture GRP products instead of "costly stainless steel and carbon steel equipments for chemical-resistance market.

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Technical Data of on-site fabrication :

- **Working Capacity : Diameter from 5M to 30M, Height up to 20M**
- **Max-Application : 2000 m^3, 16M dia x 10M Height**
- **Manufacture Code: ASME RTP-1, ASTM D -3299, NBS PS 15-69, BS 4994, CNS 11656-K308**
- **Resin to be used: Novolac Vinyl ester, Epoxy Vinyl ester, Halogenated Resin, Het acid resin**
- **Fiberglass to be used: Nexus Polyester Tissue, C-veil, Chopped strand mat, Woven roving, Filament hoop roving**
- **Helical winding angle: 10-15 degree relative to circumference**
- **Physical properties: ASTM requirement to be matched**

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LAMINATE

Characters of kigent on-site fabrication

- **No-limits of tank's diameter. Only 6-10 pcs of FRP pipes required to support steel or wooden mold**

- **No-vibration of rotation caused by driven motor to affect mold stability**

Supporting poles or frames: No-R.C. Foundation required for mold or machinery supporting

- **Fast fabrication: 4-8 days supposed only to produce one segment for 100 m^3 FRP tank**

- **Fast erection & lifting : 4-8 working days only for 1000 m^3 FRP tank**

- **Working labors required: 5-10 persons for one 1000 m^3 FRP Tank**

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TANK FARM

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(TANKS, VESSELS, AND EXHAUST SYSTEMS WITH DIMENSIONS BELOW 5 M DIA X 15 M LENGTH)

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VIEW OF THE KIGENT WORKS

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PRESSURE VESSEL – VAC TESTED

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VIEW OF TANK ERECTION

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FILAMENT WINDING PROCESS

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GRP TANK ERECTION

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Field-fabrication FRP tanks

- 6-30 M dia X 10-15 M Height

Consideration before fabrication

- **Resin selection**

In order to select the suitable resin to resist the chemical corrosion, we do concern about the specimens dipping test especially in the industrial waste water. It might contain some trifing chemicals but damage FRP structure or affect the service life.

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Normally before fabrication, we shall test

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Put various resin casting as specimens and dip it on various chemicals at elevated temperature to observe the colour change, and determine suitable resin to be used to match the chemical environment requirement.

Barcol hardness test to analyse the laminate strength reduction that caused by curing systems, percentage of hardeners, or soften by chemicals.
Check the weight loss and calculate corrosion rate, to calculate the service life.

Test results to determine the thickness of the anti-corrosion barrier and make sure the service life.

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Normally the guarantee for the products is up to 5 years, and the service life that definite by corrosion rate per corrosion barrier shall be more than 50 years:

			LENGTH	WIDTH	THICKNESS	SURFACE AREA	ORIGINAL WEIGHT W0	FINAL WEIGHT W1
		(^{0}C)	(mm)	(mm)	(mm)	(mm2)	(g)	(g)
Test 1-1	73% H2S04(aq)	45^{0}C	10.78	23.49	3.08	718	0.9159	0.9112
Test 1-2			11.19	24.32	3.2	772	0.9787	0.9735
Test 2-1	49.1% H2S04(aq)		10.62	23.03	3.12	699	0.8817	0.8796
Test 1-1			10.70	24.73	3.08	747	0.9525	0.9502

ORIGINAL WEIGHT W0	FINAL WEIGHT W1	WEIGHT LOST (W0-W1)	(W0-W1*1000/DENSITY (G/CM3)	Corrosion Rate	Corrosion Rate
(g)	(g)	(g)	(mm3)	mm/week	mm/year
0.9159	0.9112	0.0047	4.02	0.006	0.291
0.9787	0.9735	0.0052	4.44	0.006	0.300
0.8817	0.8796	0.0021	1.79	0.003	0.134
0.9525	0.9502	0.0023	1.97	0.003	0.137

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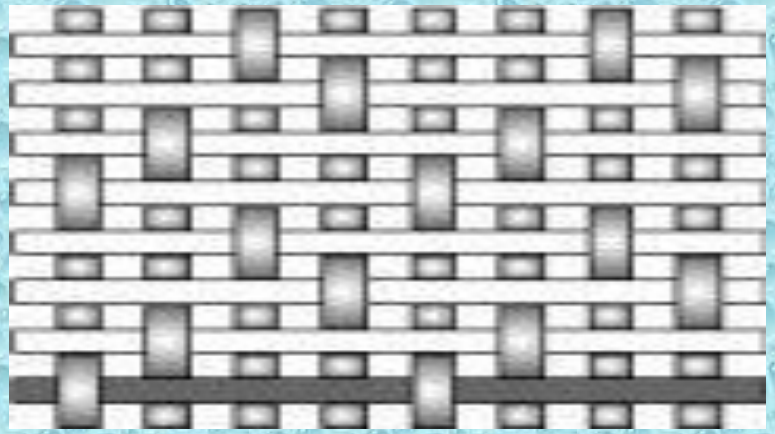
Fiberglass selection

In order to maximize service life and protect the inner layer from industrial waste water that contains various kinds of corrosive acids, caustic alkalinity, or solvent chemicals, normally double synthetic veil should be used in the corrosion barrier to prevent attack caused by the trifling caustic, solvent or corrode the inner fiberglass from Hydrofluoric Acid. The synthetic veil also provides toughness at elevated toughness at elevated temperatures and acidic oxidizing environments.

A VIEW OF RAW MATERIALS



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RAW MATERIALS-VEIL,WR

a. Glass veil made from Germany or double synthetic veil Polyester Tissue will be used for Inner liner contacted layers.

b. Woven roving should be used to increase impact strength and avoid delamination during fabrication.

c. Typical Properties of Kigent laminate.

Typical Properties of Post-cured(DM), 25mm(1”) Laminate

Property	SI	US Standard	Test Method
Tensile Strength	130 Mpa	19,000 psi.	ASTM D-3039/ISO 527
Tensil Modulus	12 GPa	1.7 x 1000000 psi	ASTM D-3039/ISO 527
Flexural Strength	210 MPa	30,000 psi.	ASTM D-790/ISO 178
Flexural Modulus	8.5 GPa	1.2x1000000psi	ASTM D-790/ISO 178
Glass Content	40%	40%	ASTM D-2584/ISO 1172

25 mm(1”) construction – 3t CR + Reinforced layers.

M= Chopped strand mat, Fw= Glass roving; 3200 g/m2 by Hoop winding and Helical winding. Wr= Woven roving, 800 g/m2

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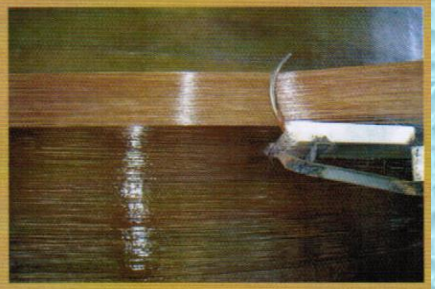
· Manufacturing procedure

Steel mold prepared & fixed.

Corrosion barrier, 3mmt applied.



Hoop F.W to be used.

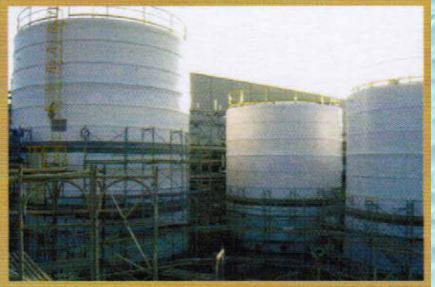
Woven roving used after Hoop.

Helical filament winding process.

Total filament-wound finished.

On site pre-assembly before shiping.

Lifting to foundation & erection



Segments jointed & hydrotested.

STEPWISE PROCESS

Advantages of Helical FW Process

a. Good strength in axial and longitudinal directions; excellent vacuum resistance; not easy to rupture; no safety worry, and specified in ASTM D-3299

b. Good seismic resistance; suitable for fabricating extra-large FRP storage tanks

c. Keep high flexural ability, when the height & diameter ratio is greater than 2

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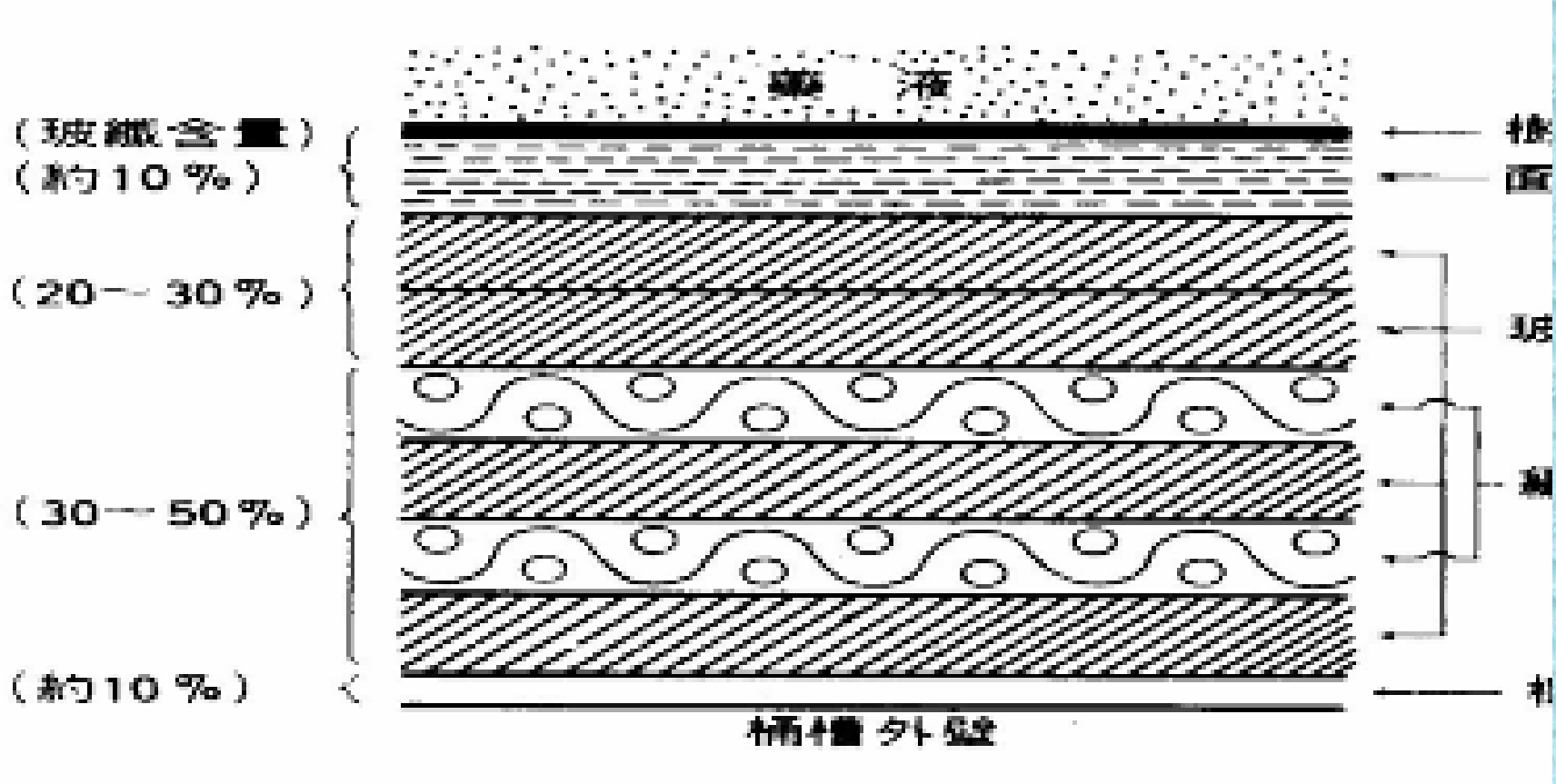
Laminate construction:

Fiberglass content and sequence



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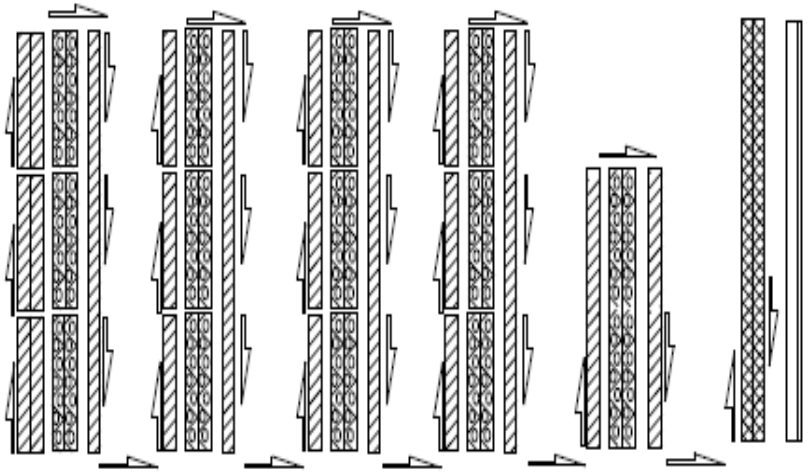
b. Laminates procedure for filament winding process.



SM : Surfacing Mat, 30g/m2, 0.25m/ ply.

CSM :Chopped Strand Mat, 300g/m2, 0.6mm/ply.

WR :Woven Roving,800g/m2, 0.8mm/ply.

Hp : Hoop Winding , 1600g/m2, 1.5mm/ply.

Hx : Helex Winding , 1600g/m2, 1.5mm/ply.

TC : Top Coating, 0.25mm/ply.

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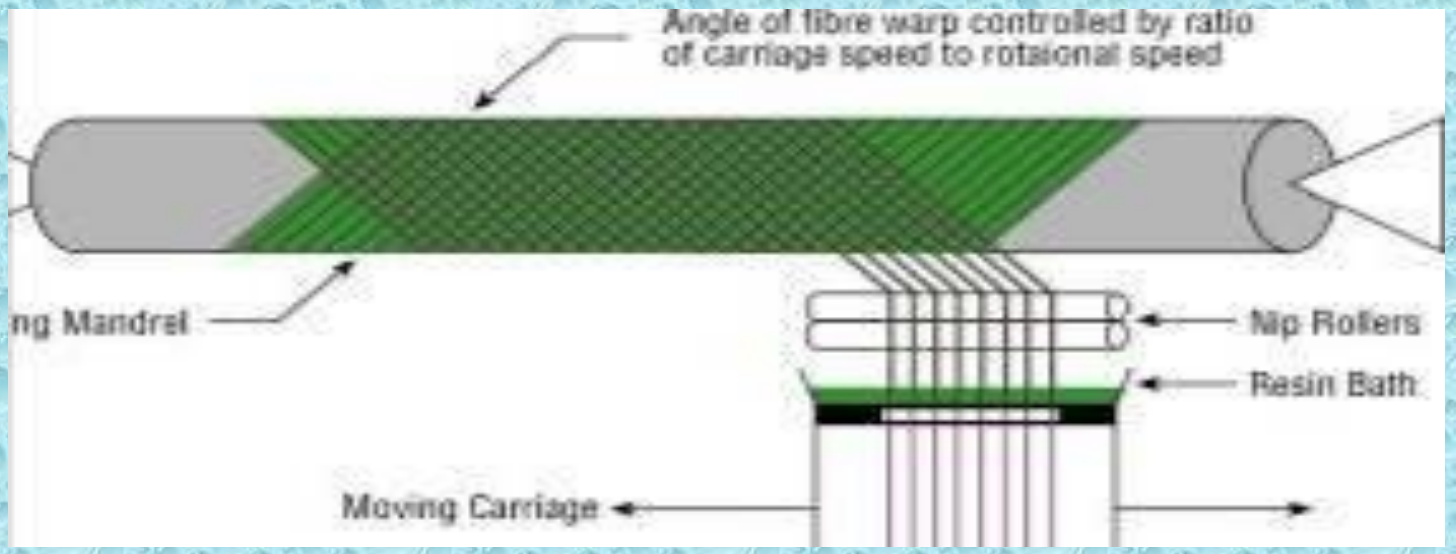

Character of Kigent Helical FW Process

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The laminate contains woven roving, hoop winding & helical winding on tank to provide high flexural & tensile strength for FRP huge tanks to resist earthquake moment or vibration of liquid vortex.

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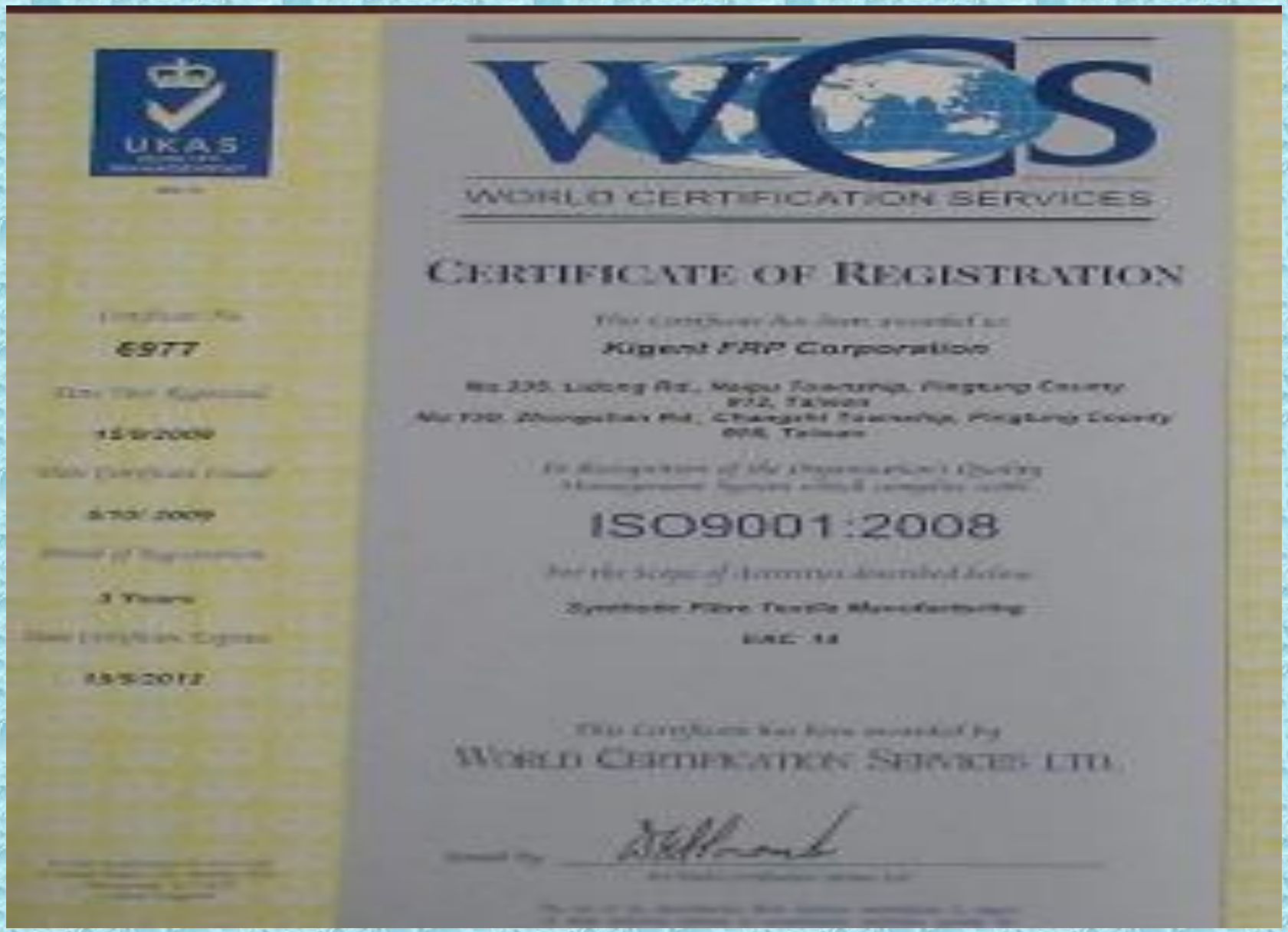
Quality System:
WCS ISO-9001: 2008 Quality Certification

- Process quality control
- Delivery quality control
- Process capability statistics and analysis
- Internal quality auditing
- Customer complaints handling
- Failure and quality variation handling procedure
- Management auditing procedure
- Feeding stock quality control



WORLD CERTIFICATION SERVICES

CERTIFICATE OF REGISTRATION

E977

15/9/2009

3/10/2009

3 Years

15/9/2012

Xigent FRP Corporation

ISO9001:2008

Synthetic Fibre Textile Manufacturing

EAC 18

WORLD CERTIFICATION SERVICES LTD.

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Comparison of different materials used for 4600m^3 waste water tank When FRP or metal lined with others and panels to be considered

4600m3 waste water tank	FRP tank	Carbon steel Lined w/ rubber	Carbon steel Lined w/FRP	SS 316 Tank	FRP Panel tank
Corrosion resistance	Excellent	Inside: Excellent Outside: Poor	Inside: Excellent Outside: Poor	Excellent	FRP: Excellent Supports: Poor
Maintenance	none	Periodic	Periodic	none	FRP panels: No Supports: Poor Gaskets: Poor
Aging by thermal stress	Good: 3% less aging. Non peeling.	Poor Rubber: Aging Easy to peel off	Poor 3% less aging. Easy to peel off	No Aging	FRP panels: 3% less aging. Gaskets: Poor
Welding points	none	Corroded on seams	Corroded on seams	Corroded on seams	Corroded on Supports
Duration for Construction	4-6months per one set	8-10months	8-10months	4-6months	4-6months
Service Life	50years more	20years less	20years less	50years more	20years less
Cost	100 %（approx）	150 %（approx）	150 %（approx）	300 %（approx）	100 %(approx）

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STEPS IN KIGENT TECHNOLOGY

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FILAMENT WINDING – IN ACTION

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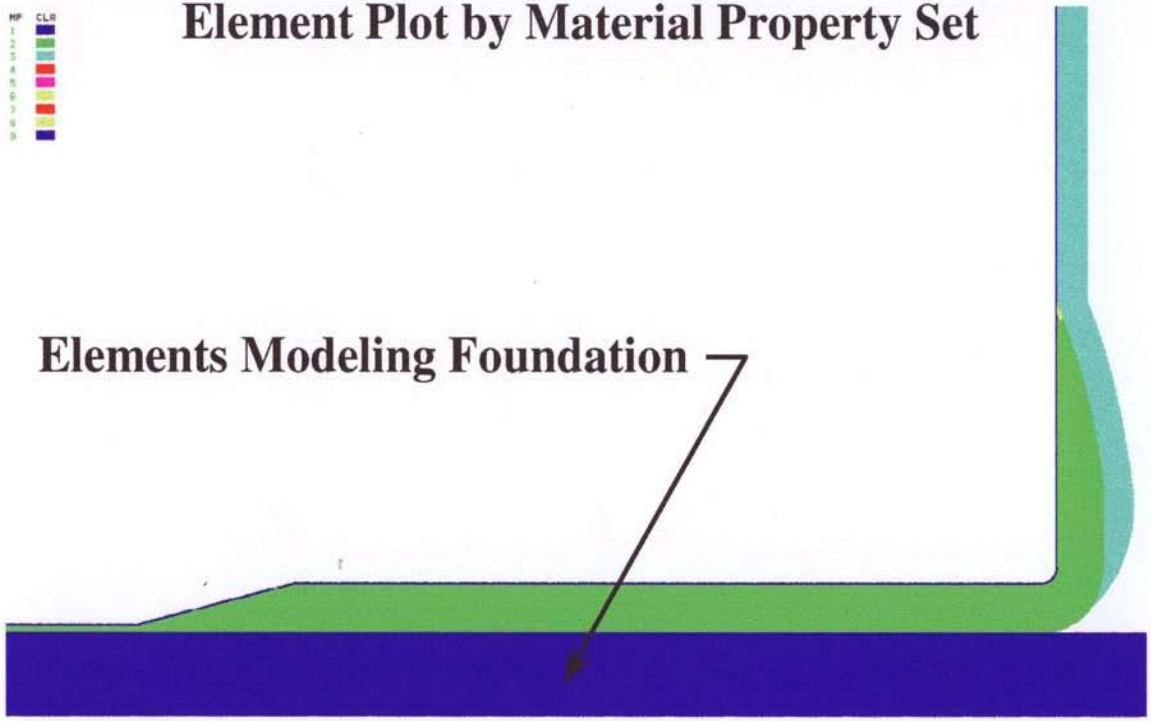
Non-Linear Axi-Symmetric FEA Design of Flat Bottom Knuckle
Pt Gunung Putri – Pt Karya Prajona Nelayan
Fiberglass FRP Phosphoric Acid Tank – 20 m ϕ x 20 m
Element Plot by Material Property Set



Al Newberry— DESIGNED THE GRP TANK

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Wound On Knuckle

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ERECTION OF TANK IN PROGRESS

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Joining Shell With Bottom Knuckle

- The FEA model was for a simplified dished head since the detailed dished head design has been done with a separate FEA.
- Since seismic loading will allow only one plane of symmetry one half of the vessel was modeled.
- The center section of the flat bottom needed not be modeled so this area was not filled with element in order to reduce the size of the model.
- The perimeter of this area was restrained in order to make the model mathematically stable.
- The shell was designed for two load cases. The first load case was hydrostatic head pressure
- The second load case was for hydrostatic head plus seismic acceleration. The seismic zone used was zone 3
- . The analysis was performed using COSMOS M Version
- . Design Evaluated by Mr.Al Newberry

TANK UNDER ERECTION

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Joining Shell To Shell

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GRP TANK UNDER ERECTION

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- **The dished top cover was fabricated in 16 segments with a crown radius of 20 m and a knuckle radius of 350 mm.**

- **The inside height of the dish was 2883 mm.**

- **Each segment was stiffened with a trapezoidal stiffener.**

- **The stiffener core size was 230 mm high, 125 mm for the crown and 200 mm for the base.**

- **The stiffener overlay thickness was 13.6 mm and was extended out onto the dish by 150 mm minimum.**

TOP DISH END -DETAILS

GRP TANK TOP DISHEND UNDER ERECTION

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JOINING THE COVER WITH THE SHELL

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GRP TANK TOP DISHEND UNDER ERECTION

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KIGENT VS OTHERS

	Others	Kigent Corp, Ltd.
Machine design	Steel mold bolted on center pole	Steel mold stand on ground
	Mold rotated by driven vehicle	None
	No machine rotation	Machine rotates along steel rail
Limitation	A huge RC foundation required to buried to keep the balance of the center pole	No RC foundation required
	Tank's diameter is limited by the weight of mold and FRP tank, the heavy weight Only loaded on the center pole	No–limits to tanks diameter due to weight of Mold & FRP tank stands on ground
	Vibration caused by driven motor to affect mold stability and balance	No vibration (because the steel mold stand on ground)
	Laminate forming to be affected by unstable mold, when mold rotation.	None
	Laminate easily collapsed or demolded to destroy the strength before curing	None
FW angle	90^0 degree by hoop winding only	80^0 degree by helical winding interactively

Advantages of Kigent process

- No-limits to tank's diameter : 30 m dia x 15 m H. 10000 M^3 FRP tank is available
- Supporting poles or frames: No R.C. foundation required to machinery supporting
- No-vibration or rotation: By driven subject to affect mold stability

Inspection methods

Solvent Test

Hydrotest

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Torsion Test

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Pressure Test

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Thanking for the patience to know about a new concept to fabricate successfully large GRP/FRP tanks to save valuable land space/ time savings /manual labour which save cost in the new environment of Green energy era.

(Every Penny saved in construction material, land area gives satisfaction as the new generation will enjoy the fruit of savings)

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