Feasibility of Novel Quadric (Egg-Shaped) Sludge Digesters within Wastewater Treatment Plants Hydraulic Infrastructure across the Caribbean.

Kiran Tota-Maharaj[1] and Navin Ramroop[1,2]

[1] University of Greenwich; Faculty of Engineering & Science, Department of Engineering Science, University of Greenwich, Pembroke, Medway Campus, Central Avenue, Chatham Maritime, Kent ME4 4TB, U.K.

[2] Centre for Project Management and Civil Infrastructure Systems, University of Trinidad and Tobago, San Fernando Technical Institute Campus, Tarouba Road, San Fernando, Trinidad. West Indies.

WHAT IS A QUADRIC-SHAPED SLUDGE DIGESTER (QSD)

Newton Creek, NYC.
Stainless Steel Digester

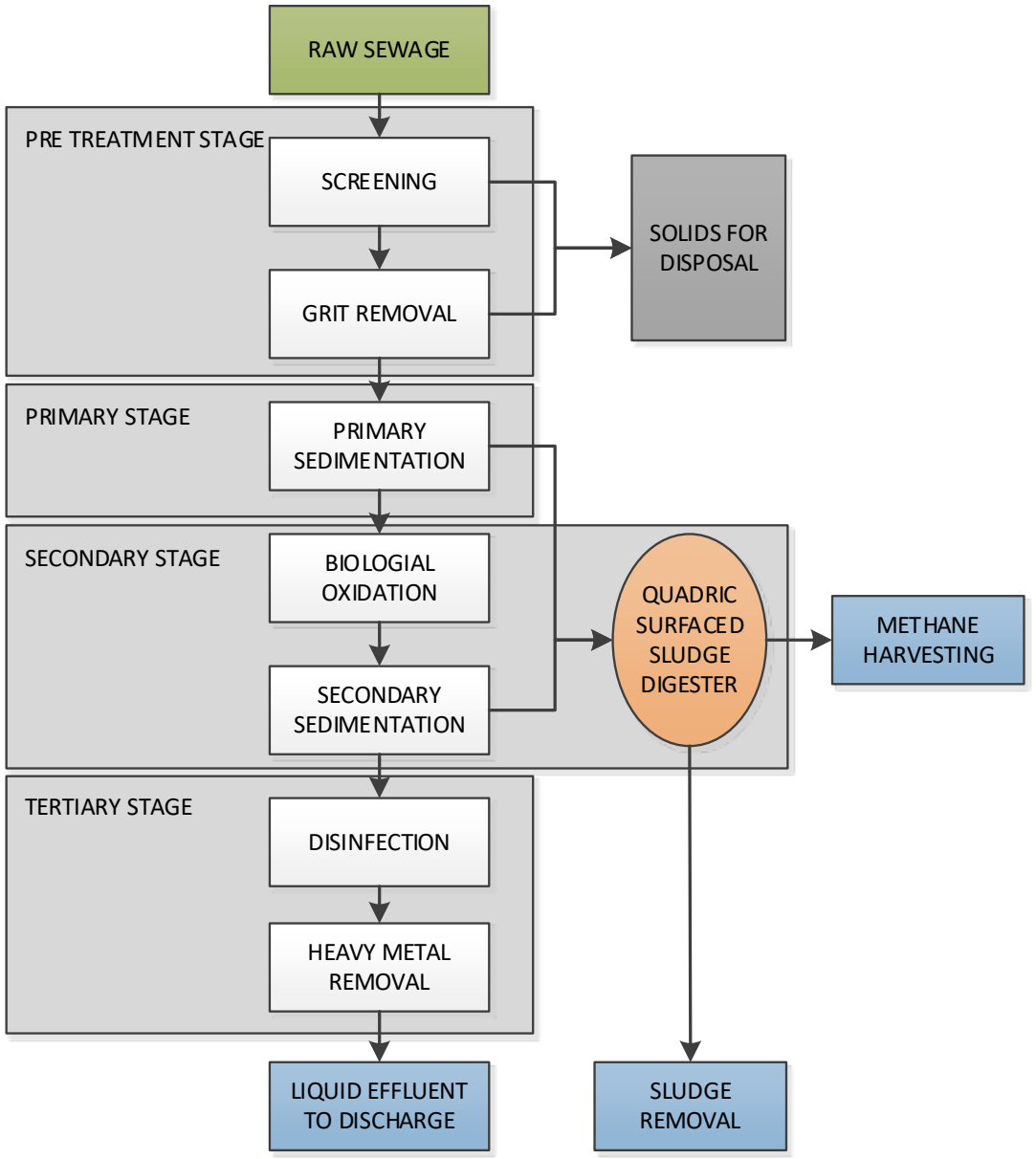
- Infrastructural component in secondary treatment of waste water.

- Its general shell form can be descried as a revolution of a parabola with its tapered ends either curved or conical.

THE QUADRIC SURFACED DIGESTER (QSD)

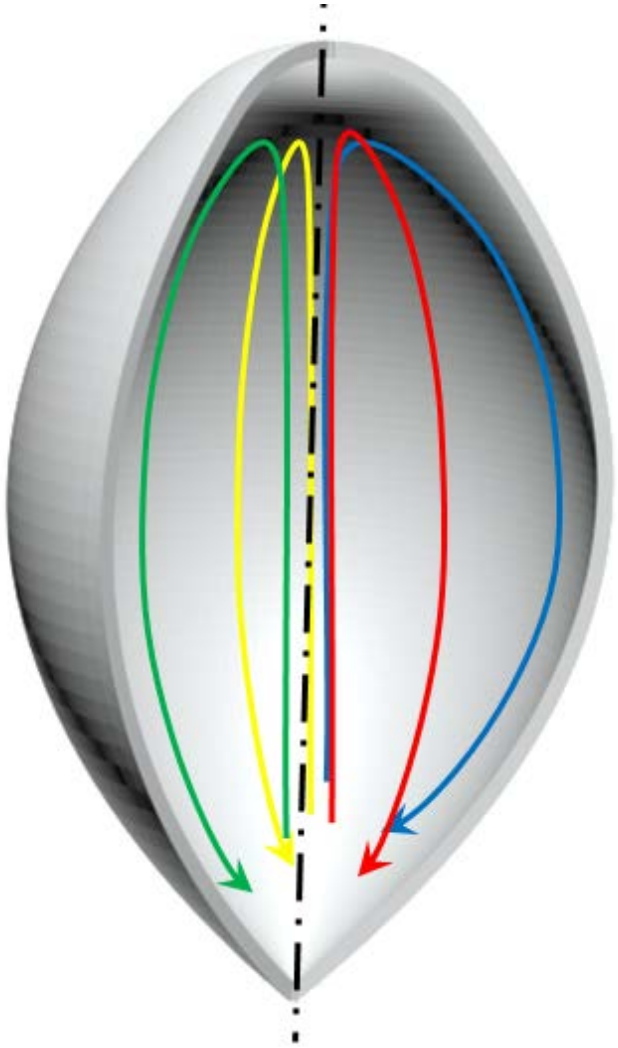
Reading Sewage Treatment Works
Reading, UK

Deer Island Waste Water Treatment Plant
Deer Island, USA

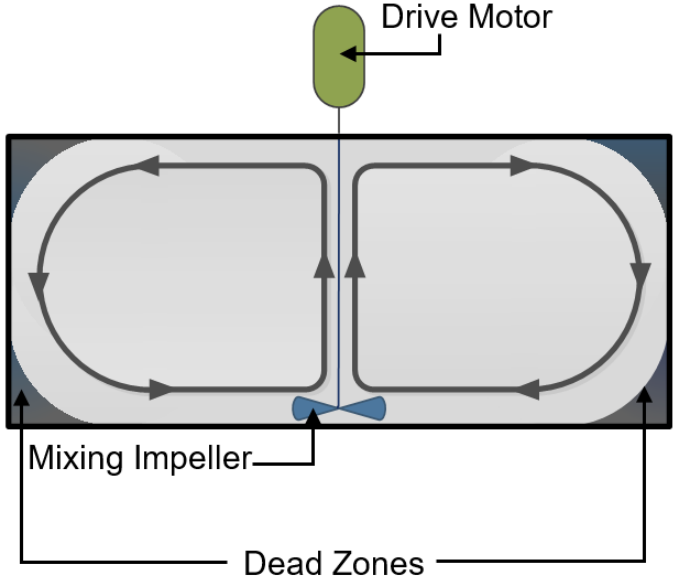


STAGES IN WASTEWATER TREATMENT PLANTS

WHY USE THE QSD?



- Efficient mixing leads to lower maintenance costs
- No downtime for cleaning
- Easy removal of settled sludge
- Efficient surface scum control



FORM

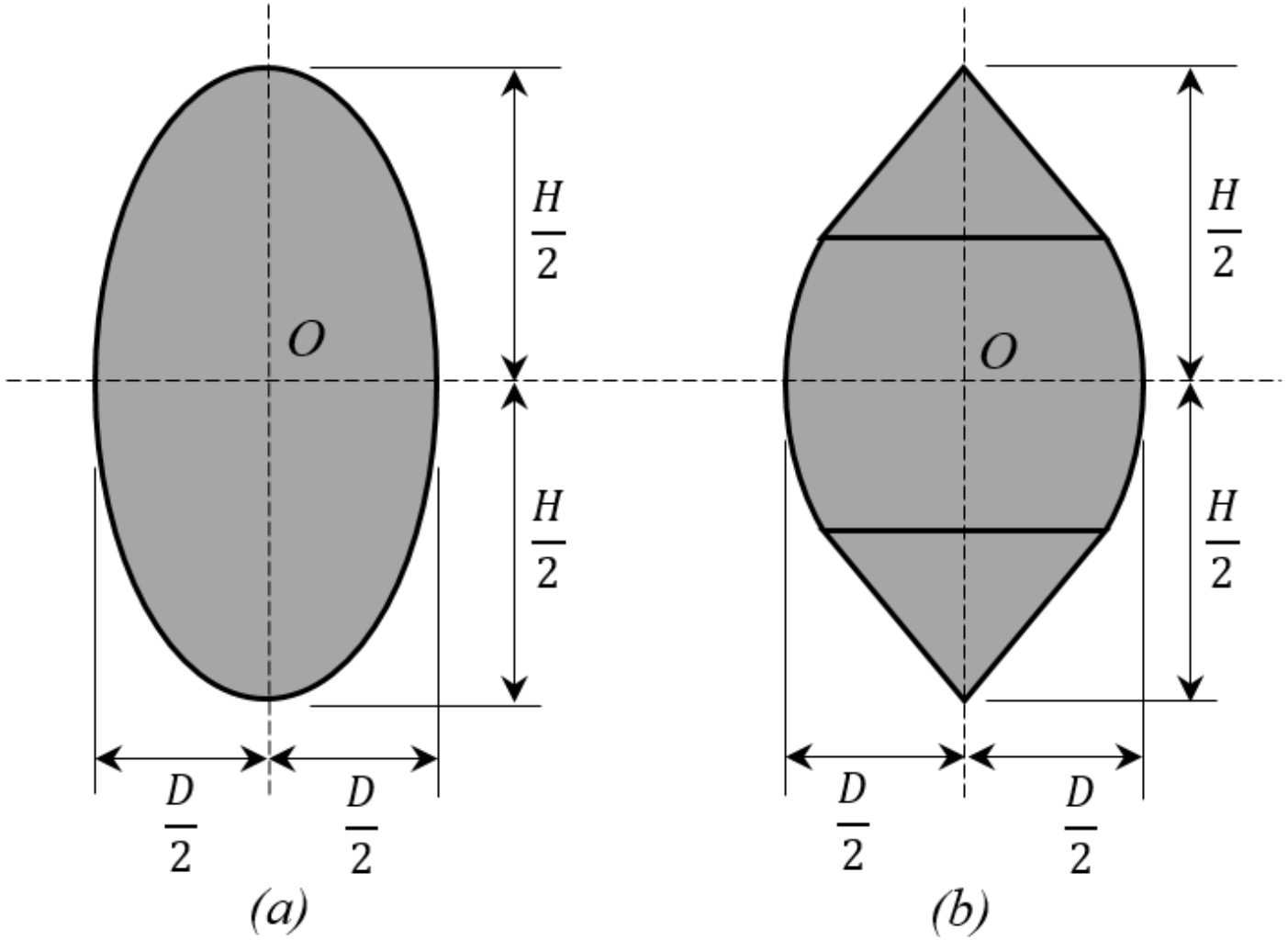


Figure 3 – (a) Spherical ogival shell with spherical closures, (b) Parabolic ogival shell

FORM

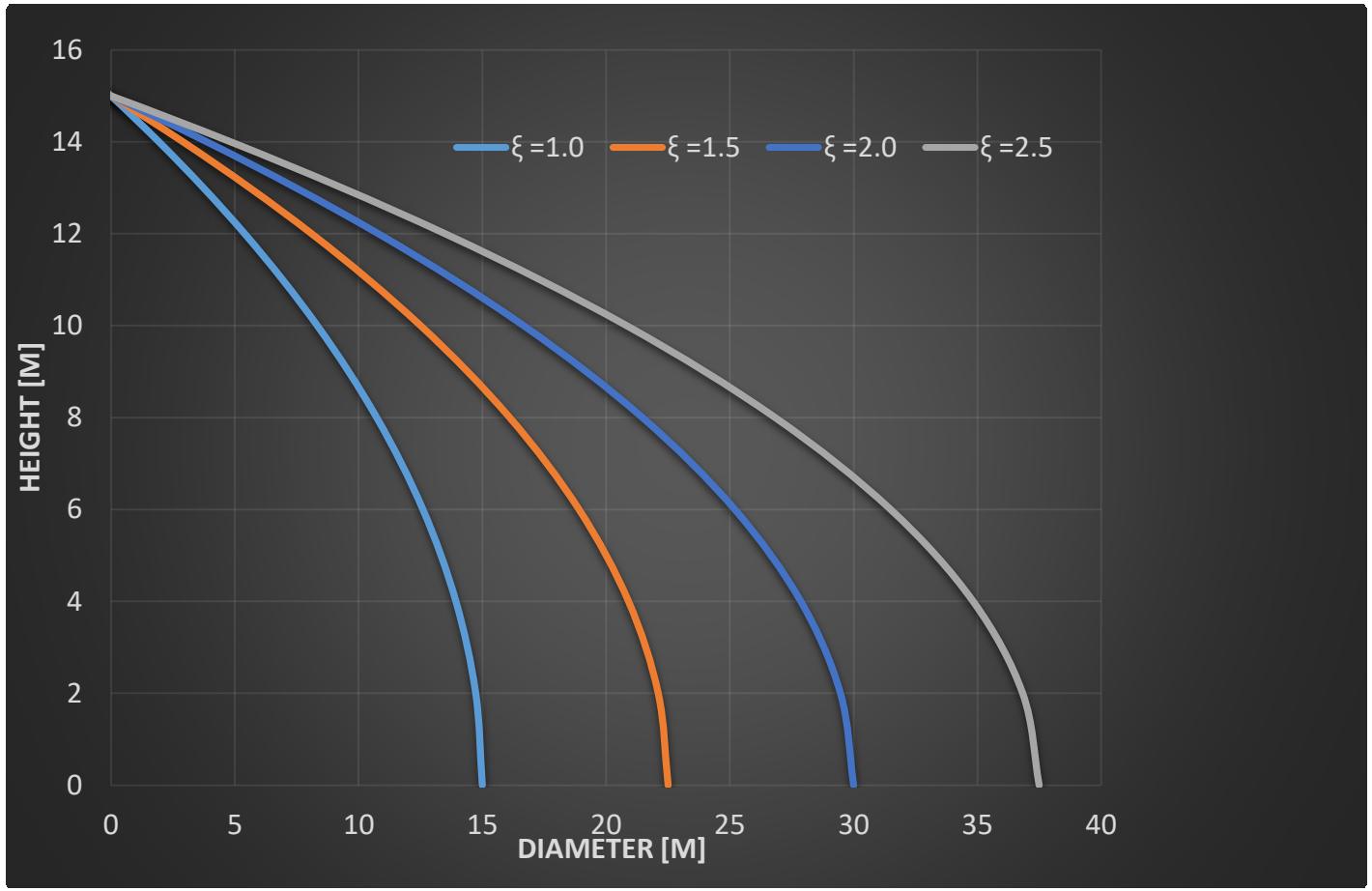
$$x = \left(\frac{D}{2}\right) - \left[\frac{(2\times D)}{H^3}\right] y^2$$

where: D = the diameter of the tank

H = the height of the tank

x = the x-coordinate of the profile

y = the y-coordinate of the profile



STRUCTURAL EFFICIENCY

$$\frac{N_\phi}{\gamma H^2} = \frac{\xi}{16}\left(\frac{\sin\phi}{4\sin^2\phi - \xi^2\cos^2\phi}\right)\left[-\left(\frac{4+\xi^2}{\sin^2\phi}\right)+\left(\frac{\xi^2}{2\sin^4\phi}\right)-\xi(4+\xi^2)\left(\frac{\cos\phi}{\sin\phi}\right)+\frac{\xi}{3}(4+2\xi^2)\left(\frac{\cos\phi}{\sin^3\phi}\right)(1+2\sin^2\phi)-\frac{\xi^3}{15}\left(\frac{\cos\phi}{\sin^5\phi}\right)(3+4\sin^2\phi+8\sin^4\phi)+\frac{1}{30\xi^2}(112+120\xi^2+15\xi^4)\right]$$

$$\frac{N_\theta}{\gamma H^2} = \frac{1}{32\xi^2}(4\sin^2\phi - \xi^2\cos^2\phi)\left[\left(\frac{2\xi\sin\phi - \xi^2\cos\phi}{\sin^4\phi}\right)-\left(\frac{\xi\sin\phi}{4\sin^2\phi - \xi^2\cos^2\phi}\right)\times\left[-\left(\frac{4+\xi^2}{\sin^2\phi}\right)+\left(\frac{\xi^2}{2\sin^4\phi}\right)-\xi(4+\xi^2)\left(\frac{\cos\phi}{\sin\phi}\right)+\frac{\xi}{3}(4+2\xi^2)\left(\frac{\cos\phi}{\sin^3\phi}\right)(1+2\sin^2\phi)-\frac{\xi^3}{15}\left(\frac{\cos\phi}{\sin^5\phi}\right)(3+4\sin^2\phi+8\sin^4\phi)+\frac{1}{30\xi^2}(112+120\xi^2+15\xi^4)\right]\right]$$

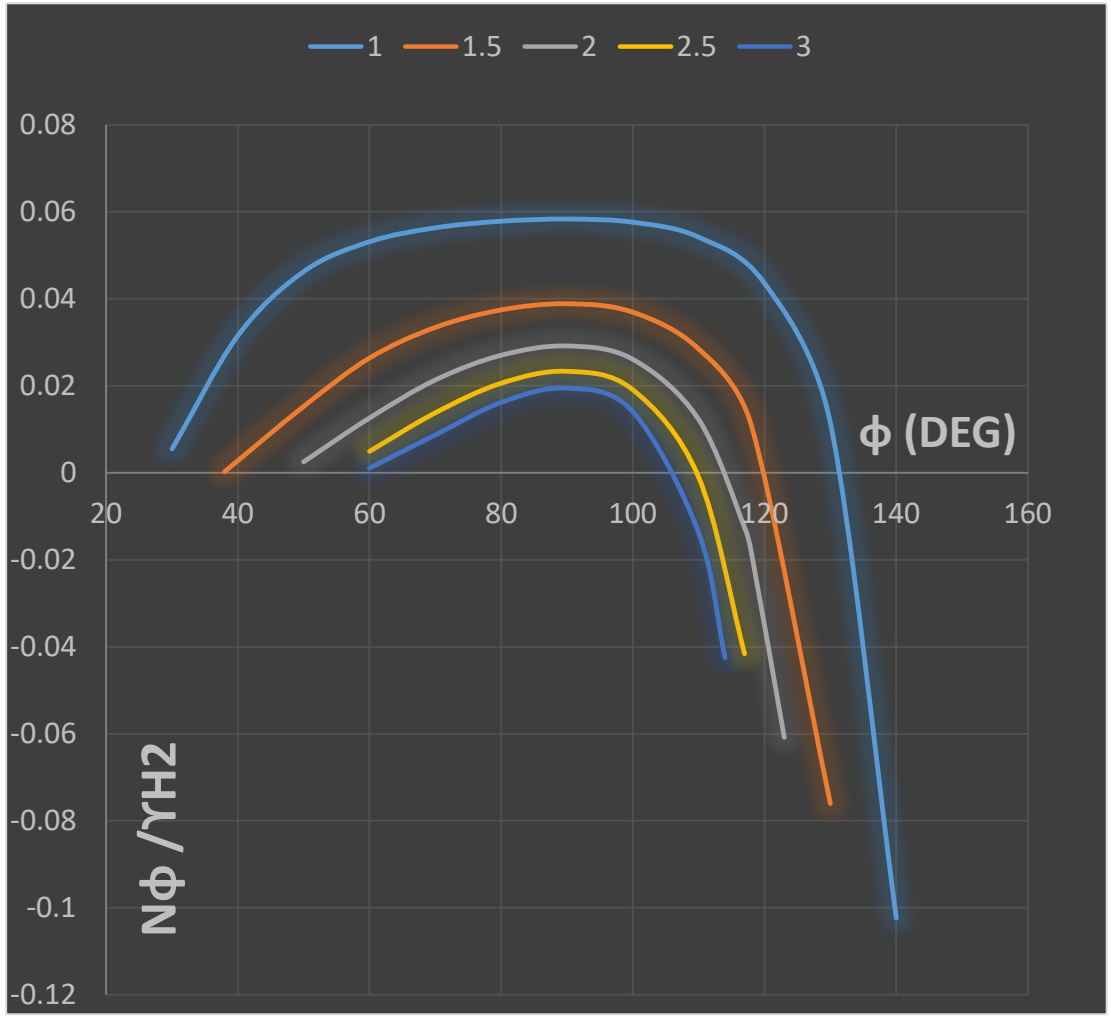
where N_φ *= the meridional stress within the shell*

N_Θ *= the hoop stress within the shell*

ξ *= H/D (height to diameter ratio)*

γ *= density of the shell*

STRUCTURAL EFFICIENCY



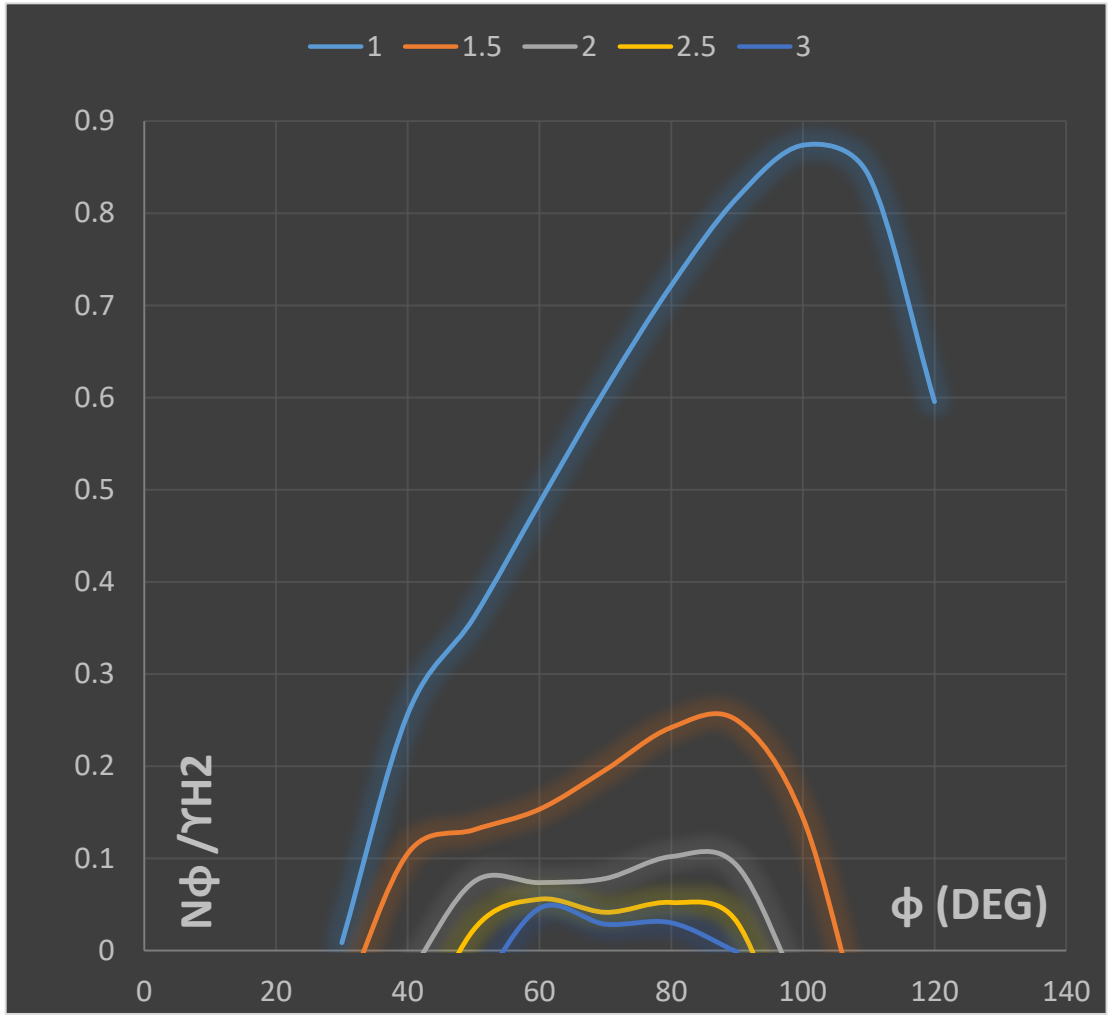


Figure 5 – Non-dimensional stress variations- (a)Meridional (b)Hoop

STRUCTURAL EFFICIENCY

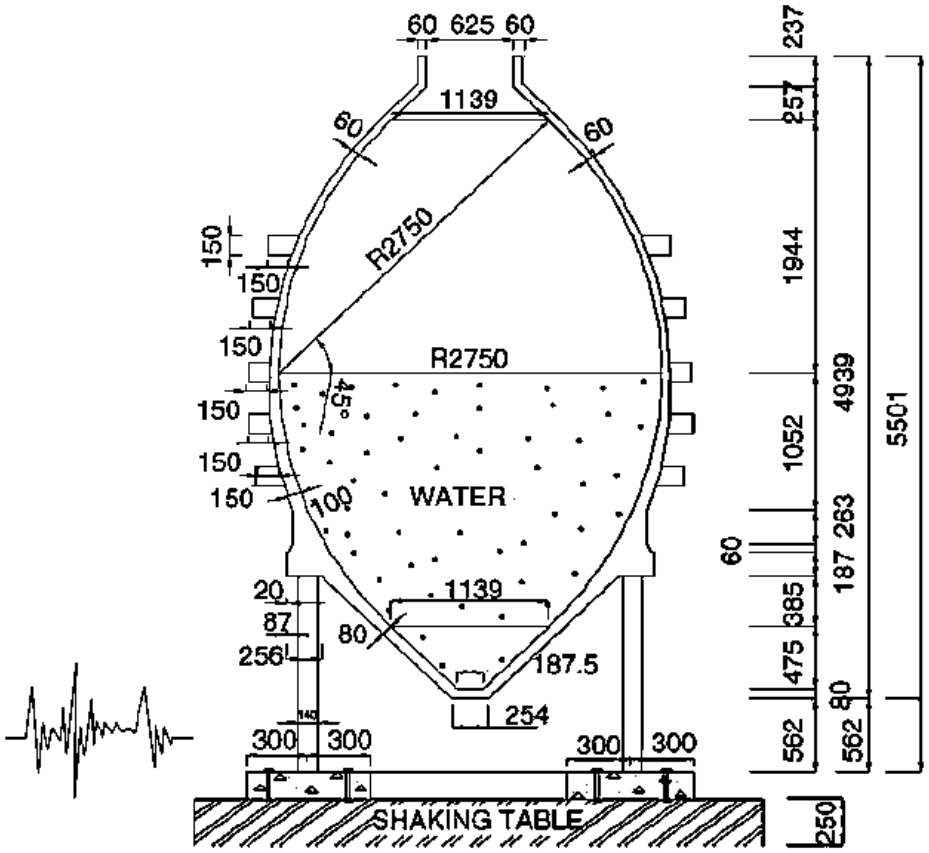


Figure 6 – ESD model under shake table test (Li, et al., 2007)

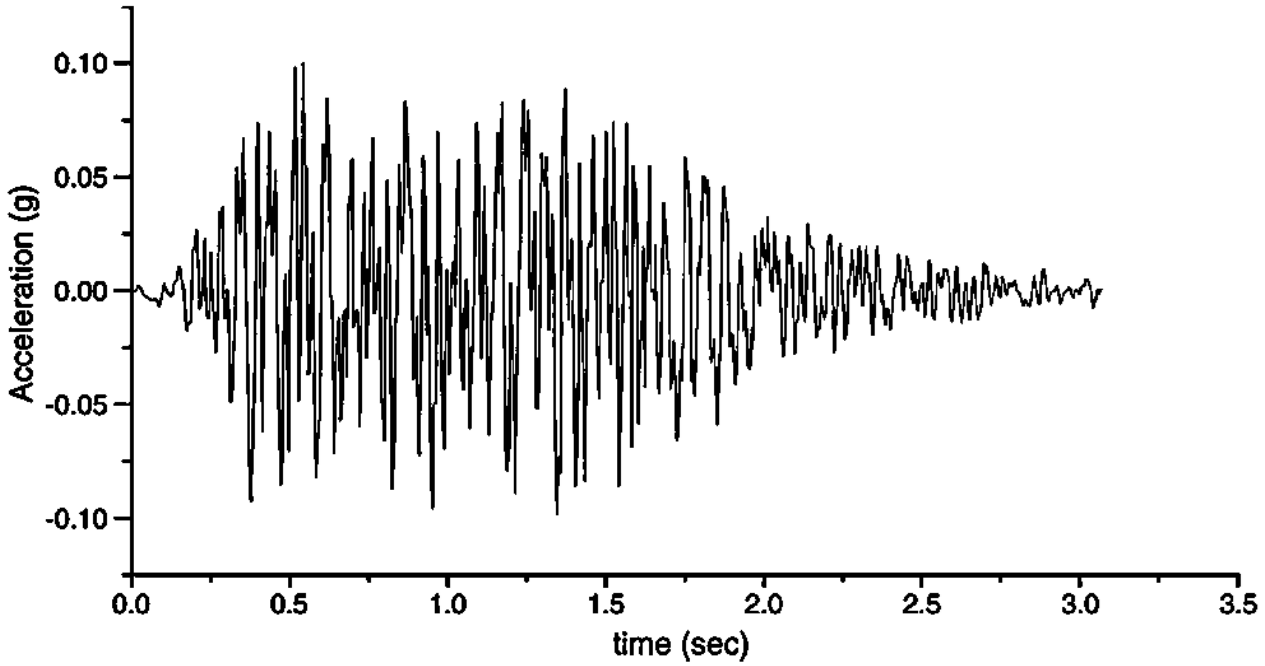


Figure 7 – Time history data of acceleration in Guangzhou (Li, et al., 2007)

MATERIALS

Two main types of materials are used:

1. Prestressed Concrete
2. Welded Steel

Country	Location	Number of tanks	Volume [m^3]	Material
Australia	Pertyh	2	2,700	Prestressed Concrete
Austria	Fritzens	2	2,700	Prestressed Concrete
Germany	Bottrop	4	5,000	Prestressed Concrete
Japan	Kumamoto	2	3,300	Prestressed Concrete
Singapore	Kranji	3	10,000	Prestressed Concrete
USA	Baltimore	2	11,350	Prestressed Concrete
USA	New York	4	293,000	Prestressed Concrete
USA	Utah	2	6,245	Welded Steel

CONCLUSION AND OUTLOOK

The quadric surfaced sludge digester has been used satisfactorily in the secondary treatment of wastewater sludge. Despite having higher construction costs, the benefits due to its shape translates to an overall cost reduction during operation and maintenance. Further research is currently being conducted in developing the structural form such that the initial construction cost can be further reduced, hence making the QSD readily available and practical for small island developing states (SIDS) across the Caribbean region.

ONGOING RESEARCH

3D PRINTING APPLICATIONS	QSD WALL SECTION DEVELOPMENT	QSD PREFORMANCE
• ANALYSE A SUITABLE GEOMETRIC MESOSTRUCTURE BY NUMERICAL AND EXPERIMENTAL ANALYSIS	• EXAMINE GEOMETRY OF CANCELLOUS BONE. • IDEALISE BONE GEOMETRY • APPLY 3D PRTINTED MICROSTRUCTURE AND ANALYSE IDEALISED MODEL NUMERICALLY. • 3D-PRINT AND TEST MODELS.	• CHOOSE OPTIMUM GLOBAL QSD FORM • APPLY DEVELOPED WALL SECTION AND ANALYSE GLOBAL QSD BY NUMERICAL ANALYSIS. • 3D PRINT GLOBAL MODEL AND PREFORM DYNAMIC TESTS.

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Acknowledgments

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