

# FERRO10

X SIMPOSIO INTERNACIONAL  
DEL FERROCEMENTO  
Y COMPUESTOS DELGADOS  
DE CEMENTO REFORZADO

10th INTERNATIONAL SYMPOSIUM  
ON FERROCEMENT  
AND THIN REINFORCED  
CEMENT COMPOSITES

Palacio de Convenciones  
La Habana, Cuba  
15-17 de octubre de 2012

*Una tecnología apropiada y sostenible  
para países en desarrollo*

*Ferro cement an Appropriate  
and Sustainable Technology for under  
Development Countries*

## Editores

Hugo Wainshtok Rivas  
Lázaro Prada Seoane  
Iria Granda Castro

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**FERRO 10**

X Simposio Internacional del Ferrocemento y Compuestos Delgados de Cemento Reforzado  
La Habana, Cuba 15-17 de octubre de 2012

**Editado por:**

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# Índice

# Índice

# Prólogo 14

## I

### Nuevos materiales y tecnologías New Materials and Technologies

<b>Compatibility study of pvc-coated weld mesh in thin reinforced cementitious matrix</b>	<b>17</b>
P.B. Sakthivel and A. Jagannathan	
<b>Material characterization of fiber reinforced cementitious matrix (FRCM) composite laminates</b>	<b>29</b>
Diana Arboleda, Givani Loreto, Antonio De Luca and Antonio Nanni	
<b>Uso de las fibras orgánicas en paneles ligeros</b>	<b>39</b>
Jorge Bernardo Acevedo Catá e Inocente Bojórquez Báez	
<b>Textile Reinforced Concrete-Providing sustainability for flexible urban concepts</b>	<b>49</b>
Silke Tomoscheit and Thomas Griesz	
<b>La experiencia cubana con el empleo del fibrequén</b>	<b>59</b>
José Alfonso Macías Mesa y María de Lourdes Artola Pimentel	
<b>Las fibras naturales una alternativa sustentable a partir del bambú en la conformación de componentes para la construcción</b>	<b>75</b>
Juan Manuel Pascual Menéndez	
<b>Rice straws as reinforcement concrete hollow blocks</b>	<b>83</b>
Isabelita T. Bautista and Lilia Robles-Austriaco	
<b>The effects of high temperature on the strength of rice husk ash concrete</b>	<b>91</b>
Manolito S. San José and Nicanor C. Austriaco	
<b>Properties of poly(vinyl alcohol) fiber reinforced high-performance organic aggregate cementitious material: converting brittle to plastic</b>	<b>97</b>
Houssam Toutanji and B. Xu	
<b>Efecto de la adición de ceniza volante sobre la resistencia química a sulfatos de cementos</b>	<b>103</b>
Daniela Eugenia Angulo, Silvia Izquierdo García, Arbeiy Cerón, Marcos Contreras y Ruby Mejía de Gutiérrez	
<b>Análisis comparativo de la durabilidad de un cemento adicionado con ceniza volante, toba volcánica y ceniza de bagazo de caña de azúcar</b>	<b>113</b>
Daniela Eugenia Angulo, Diana Marcela Burgos, William Gustavo Valencia y Ruby Mejía de Gutiérrez	
<b>Cement based composites with fibres for thin wall elements: fatigue parameters</b>	<b>123</b>
Stanislav Seitl, Zbynìk Keršner and Vlastimil Bílek	

<b>Behavior of textile reinforced concrete under compression load</b>	<b>129</b>
Frank Jesse, Thomas Unger and Mario Dambrowski	
<b>Experimental analysis on bending of cement mortar reinforced with fibre glass</b>	<b>139</b>
Mounir Khalil El Debs	

## II

# Análisis, diseño y construcción Analysis, Design and Construction

<b>Reforzamiento de una presa de ferrocemento afectada por fenómenos hidrometeorológicos extremos</b>	<b>155</b>
Margarito Ortiz Guzmán, Valentín Juventino Morales Domínguez y Manuel Dino Aragón Sulik	
<b>Fiber Reinforced Cementitious Matrix (FRCM) composites as confining systems for reinforced concrete columns</b>	<b>161</b>
Adane Abegaz, Suaris Wimal, Antonio Nanni and Antonio de Luca	
<b>Experimental and numerical investigations about Ferrocement and hybrid solutions for repairing and/or strengthening reinforced concrete beams</b>	<b>171</b>
Amir Si Larbi, Amen Agbossou and Patrice Hamelin	
<b>Reparación de estructuras con ferrocemento</b>	<b>191</b>
Hernán Eusebio Arnés Valencia	
<b>El ferrocemento en la consolidación estructural en obras de restauración</b>	<b>201</b>
Ximena Karla Santa Cruz Mérida	
<b>An application of ferrocement shell roof on rehabilitation of mosque construction after 29 years of services</b>	<b>207</b>
Alami Fikri and Junaidi Tas'an	
<b>Performance of ferrocement as flexural strengthening in rural areas</b>	<b>213</b>
S.F.A. Rafeeq, D.S.V. Khan and H.S. Lodi	
<b>Energy absorption capacity of short ferrocement columns under biaxial load</b>	<b>223</b>
Jianqi Wang, Paul Nedwell and Parthasarathi Mandal	
<b>Comportamiento experimental de muros con perfiles de acero de lámina delgada y placas de ferrocemento</b>	<b>233</b>
Patricia Aydeé Guerrero Zúñiga y Carlos Andrés Gaviria Mendoza	
<b>Flexural Behaviour of Lightweight Ferrocement Fencing Panels</b>	<b>243</b>
Rasiah Sriravindrarajah, Antonio Martín Rodríguez and Christian Ariel Gómez	
<b>Preliminary Investigation on Ultra-High Performance Ferrocement</b>	<b>251</b>
Kay Wille and Antoine E. Naaman	

<b>Shear behaviour of ferrocement beams: experimental and fem study</b>	<b>261</b>
S. Tian, Parthasarathi Mandal and Paul Nedwell	
<b>Ductility and energy absorption capacity of hybrid ferrocement hollow slabs subjected to cyclic loading</b>	<b>269</b>
D. Shoba Rajkumar, V. Rajkumar and R. Sundararajan	
<b>Stochastic cracking of composites with heterogeneous reinforcement</b>	<b>279</b>
Rostislav Rypl, Rostislav Chudoba, Miroslav Voæechovský and Josef Hegger	
<b>Posibilidades del empleo de fívicento como material de construcción</b>	<b>291</b>
J. Marco García, C. Fernández Caballero, J.A. Marco Mendívil e I. Muñoz del Toro	
<b>Generación de muros de ferrocemento a partir residuos agroindustriales</b>	<b>301</b>
Daniel Bedoya Ruiz	

### III

## Aplicación en obras de arquitectura e ingeniería Application in Architectural Works and Engineering

<b>Le Toumelin: a Successful Ferrocement Shooner</b>	<b>317</b>
Antoine E. Naaman and Pierre Brenet	
<b>Elementos flotantes de grandes dimensiones, de hormigón</b>	<b>327</b>
Enrique de Jongh Caula	
<b>Piscinas de Ferrocemento en Cuba. ¿Utopía o realidad?</b>	<b>331</b>
Hugo Wainshtok Rivas y Henry Hernández Sotomayor	
<b>Diseño y construcción de la piscina en ferrocemento de la etapa krypton de villa club</b>	<b>341</b>
Jaime Eduardo Landívar Vera	
<b>Revolutionary application of ferrocement water tanks, water treatment plants and waste water treatment plants at Minas Gerais, Brazil</b>	<b>345</b>
Bonifacio Savio Nunes	
<b>Represas de ferrocemento. Opción para retención de agua de lluvias en zonas semiáridas en la Mixteca Oaxaqueña, México</b>	<b>367</b>
Margarito Ortiz Guzmán, Manuel Dino Aragón y Valentín Morales Domínguez	
<b>Sistema de edificios residenciales sismoresistentes de ferrocemento (serf): una opción para la construcción de viviendas de interés social</b>	<b>375</b>
Hugo Wainshtok Rivas y Yen-Liu Lizazo Hernández	
<b>Elementos de ferrocemento para vivienda social</b>	<b>387</b>
Sergio Moraga	

<b>Coordinación modular y ferrocemento</b>	<b>393</b>
Germán Ignacio García Corredor	
<b>La experiencia del CIIDIR IPN en proyectos de vivienda y edificios públicos de ferrocemento en Oaxaca, México</b>	<b>419</b>
José Luis Caballero Montes, Rafael Alavés Ramírez y Tertuliano Caballero Aquino	
<b>Arquitectura orgánica</b>	<b>427</b>
Javier Senosiaín Aguilar	
<b>Superficies alabeadas y esféricas de ferrocemento</b>	<b>437</b>
Domingo Antonio Alás Rosell	
<b>El ferrocemento en obras escultóricas</b>	<b>445</b>
Ximena Karla Santa Cruz Mérida	
<b>The Plasticity of Ferrocement: It's Potential For Architectural Application and Influence on Architectural Form</b>	<b>451</b>
Anupama Kundoo	
<b>Flexibilidad funcional y plasticidad formal del ferrocemento en equipamientos recreativos: rompiendo prácticas tradicionales</b>	<b>457</b>
Huáscar Bolívar Vallejo	
<b>La morfología sin límite para la imaginación y su formación con ferrocemento</b>	<b>463</b>
Javier Rodrigo Moscoso Tejada y Karen Aranibar Miranda	
<b>Sustainable ferrocement sports hall</b>	<b>471</b>
Milenko Milinković and Mladen Milinković	
<b>Fibre-reinforced and Ferrocement Car-park Pavers</b>	<b>481</b>
Rasiah Sriravindrarajah	
<b>El ferrocemento y sus posibilidades de transporte isado de láminas para fachadas y arreglos estructurales</b>	<b>489</b>
Javier Rodrigo Moscoso Tejada	
<b>Estructura laminar compuesta</b>	<b>495</b>
Roque J. Méndez Baeza	

# IV

## Desastres, durabilidad y otros Disasters, Durability and Others

<b>Reducing the Carbon Footprint in Concrete Construction-a case study</b>	<b>503</b>
Silke Tomoscheit, Thomas Gries, Michael Horstmann and Josef Hegger	
<b>Natural disaster control with Smart Textile Reinforced Concrete</b>	<b>517</b>
Till Quadflieg, Silke Tomoscheit and Thomas Gries	
<b>Ferrocement Technology For Disaster Mitigation and Resistance</b>	<b>523</b>
J.A. Desai	
<b>Comportamiento sísmico de muros de ferrocemento</b>	<b>529</b>
Daniel Bedoya Ruiz, Diego Álvarez Marín y Gilberto Ortiz García	
<b>Modelo dinámico no lineal para el comportamiento sísmico de casas de viviendas de ferrocemento</b>	<b>545</b>
Daniel Bedoya Ruiz, Jorge E. Hurtado Gómez y Diego Álvarez Marín	
<b>Seismic fragility of ferrocement housing</b>	<b>555</b>
Daniel Bedoya Ruiz, Jorge E. Hurtado Gómez and Diego Álvarez Marín	
<b>Seismic performance of unreinforced beam-column joints strengthened using ferrocement and diagonal reinforcements at low and high axial load ratios</b>	<b>563</b>
Bo Li, Eddie Siu-shu Lam, Bo Wu and Ya-yong Wang	
<b>Elementos de ferrocemento después de 25 años de vida útil</b>	<b>575</b>
Francisco Javier Quiñónez de la Cruz	
<b>Índice de autores</b>	<b>587</b>

# Prólogo

Ferro cemento y láminas delgadas de cemento reforzadas, son esencialmente elementos de hormigón armado de menos de 5 cm de espesor. Por tal motivo sus componentes se corresponden con estos espesores y el refuerzo está sometido a una disminución en la escala, telas de mallas de alambres de pequeño diámetro en lugar de barras de acero y la matriz de mortero en lugar del hormigón.

En los últimos 50 años, los que marcan el uso moderno del ferrocemento y láminas delgadas de cemento reforzado, su análisis, diseño y construcción fueron objeto de considerables avances en: 1-El refuerzo, como la utilización de acero de alta resistencia, polímeros reforzados con fibras, textiles en 2D o 3D etc; 2-La matriz cementosa, de alta resistencia o alto desempeño, alta durabilidad, ligereza, mezclada con materiales suplementarios, aditivos auto compactantes y de muy alta resistencia; 3-La adición de fibras y microfibras como suplemento al refuerzo convencional y 4-Los procesos de construcción desde un emplastecido simple hasta procesos de extrusión, infiltración etc.

Los principales objetivos de este simposio son proveer información actualizada sobre el desarrollo y avances en la investigación en el campo del ferrocemento y compuestos delgados de cemento reforzados; permitir el intercambio de experiencias y conocimientos y visión entre especialistas del mundo entero; coordinar la colaboración e intercambio técnico entre investigadores y constructores tanto nacionales como internacionales; identificar los aspectos técnicos que necesiten una investigación a mediano o largo plazo, así como sugerir las direcciones a seguir.

El simposio se dirige en general a reforzar el criterio del ferrocemento como un material apropiado y sostenible para los países en desarrollo.

Otro particular aspecto de este simposio es la participación por primera vez en eventos de este tipo, de arquitectos cuyo diseño se vincula a una arquitectura orgánica, contando en este aspecto con profesionales de Suiza, Francia, Bolivia, México, República Dominicana, Cuba y Colombia.

En FERRO 10 se recibieron 58 trabajos de 28 países los que se han agrupado en 4 temas:

I: Nuevos materiales y tecnologías.

II: Análisis, diseño y construcción.

III: Aplicación en obras de arquitectura e ingeniería.

IV: Desastres, durabilidad y otros.

Aprovechamos esta oportunidad para agradecer a los autores que han hecho posible esta publicación y a todos aquellos que de una forma u otra han apoyado la realización de este simposio.

# AN APPLICATION OF FERROCEMENT SHELL ROOF ON REHABILITATION OF MOSQUE CONSTRUCTION AFTER 29 YEARS OF SERVICES

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## ABSTRACT

This paper presents rehabilitation of mosque construction which has been 29 years of service for moslem praying. The mosque was located at regency of Pringsewu, Province of Lampung Indonesia. It was built in 1982 and used by inhabitant surroundings for praying and people who dropped in for praying as well.

The aims of rehabilitation of the mosque are to repair parts of the mosque such as roofs, walls, window frames which damaged and to increase capacity of people who can pray at the building. In addition, growth of inhabitant surroundings encouraged the board of the mosque to expand the mosque. The rehabilitation did not only expand the mosque but also changed material of structure from predominantly wood to concrete and ferrocement material. As a results, the mosque look more robust and beautiful than previous one.

Before repaired, roof shape was constructed by wood which assembled by bolts and nails. Then zink was used to cover the roof. Wall of the mosque are made by a half brick wall and at it's wall holed by wood windows for ventilation. After repaired, roof was replaced by ferrocement shell roof elements which were supported by reinforced columns. The rehabilitation process was started from November 2010 and finished on January 2012.

The rehabilitation of the mosque with using ferrocement shell roof gave first experienced to the local laborers. The whole constructions were done by them under supervision and guidance teams from Department of Civil Engineering the University of Lampung as designer.

Keyword: ferrocement shell roof, mosque construction.

## 1. INTRODUCTION

Mosque is a palce for moslem praying. It's presence along the road much useful for moslem who are in trip to drop in for praying and take a rest for a while before continuing their journey. Hidayatullah mosque is located at side of the road at Wonokarto village, regency of Pringsewu Province of Lampung. This mosque was built in 1982 using bricks for it's wall and zinks for dome and roof with supported by wood beams.



Figure 1. Roof dome of Hidayatullah Mosque was made of aluminum zink at construction stage before removed.

<sup>1</sup>. Lecturer at Department of Civil Engineering, University of Lampung. Indonesia

Initially, the main size of the mosque was not as big as 14x17 square meter as can be seen on mosque ground plan in Figure 2. The size change of the mosque was aimed to not only expand capacity of the mosque but also make performance of structure more robust and beautiful than previous one. The change of dimension was followed by removing four prior internal columns that function as support of previous dome. By removing those internal columns, praying room becomes wider and rostrum is able to be seen from all angles of building.

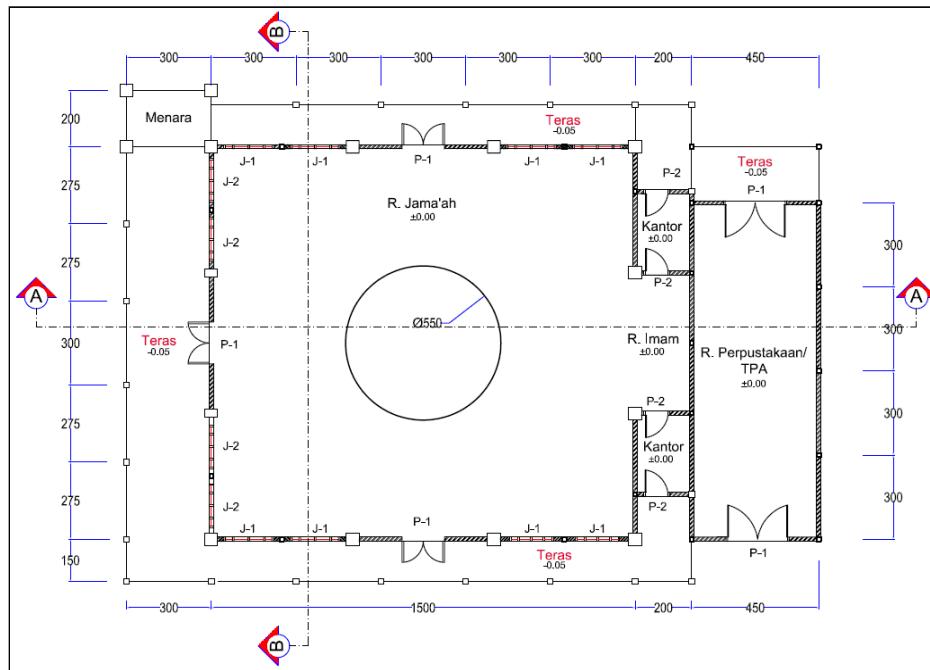


Figure 2. A new mosque ground plan.

Repairing and a big change of this mosque required enough big fund for construction. The fund for constructing this building is 1.2 billion Rupiahs (=126,316 US\$, assumed 1 US\$ = 9.500 Rupiahs). It was contributed by donaturs, people surroundings around, and people who going across the road in front of the mosque. Duration of construction need 1 years and 10 months length started from August 2010 and finished on May 2012.

## 2. FEROCEMENT CONSTRUCTIONS

Basically, construction of the mosque was a combination between reinforced concrete and ferrocement elements structure. Reinforced concrete was used to structure element that sustain bigger loads such as columns and beams, where as ferrocement was used to lighter structure such as dome and roofs.



Figure 3. Ferrocement Structure on Dome, main roofs and terrace roofs.

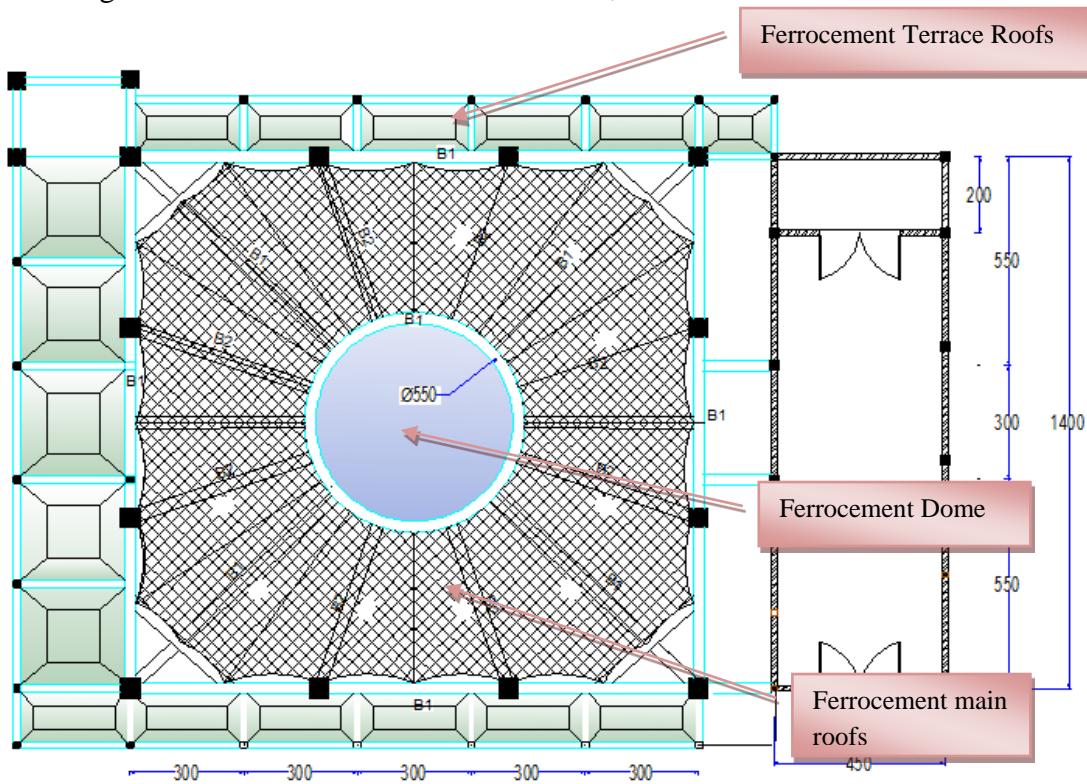


Figure 4. Sketch of Ferrocement dome and roofs.

## 2.1 Detail Construction of Ferrocement Dome and Ferrocement Wave Roofs.

Dome of this mosque has diameter of 5.5 meter with ferrocement thickness of 30 mm averagely. Reinforcement for this ferrocement dome consists of one layer of skeleton steel with diameter of 8 mm

and open space of 15 cm and 3 layers of square mesh where 1 layer on top level and 2 layers on bottom level of skeleton steel. Reinforcement of ferrocement wave roofs can be seen in Figure 5(b).

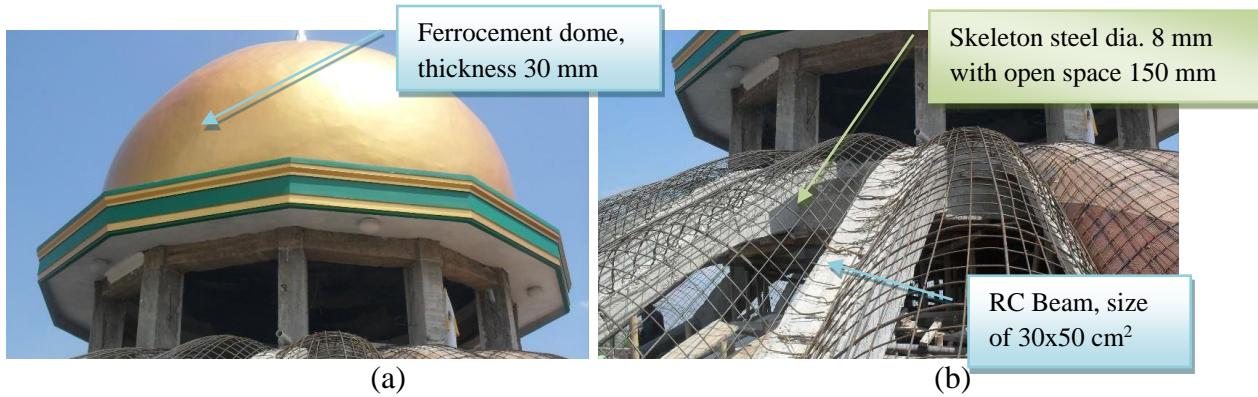


Figure 5. (a) Ferrocement Dome; (b) Reinforcement of Ferrocement wave roofs.

To cover main roof of the mosque was chosen wave shape with radius bigger at bottom side than top side as shown in Figure 6. These elements are 24 elements. Thickness of this element is 30 mm. Between two wave element roofs, there is ferrocement rib with thickness of 60 mm. This rib makes roof structure more stiff and beautiful if seen from inside of mosque. Every two roof elements are supported by RC beams with size of 30x50 cm square.

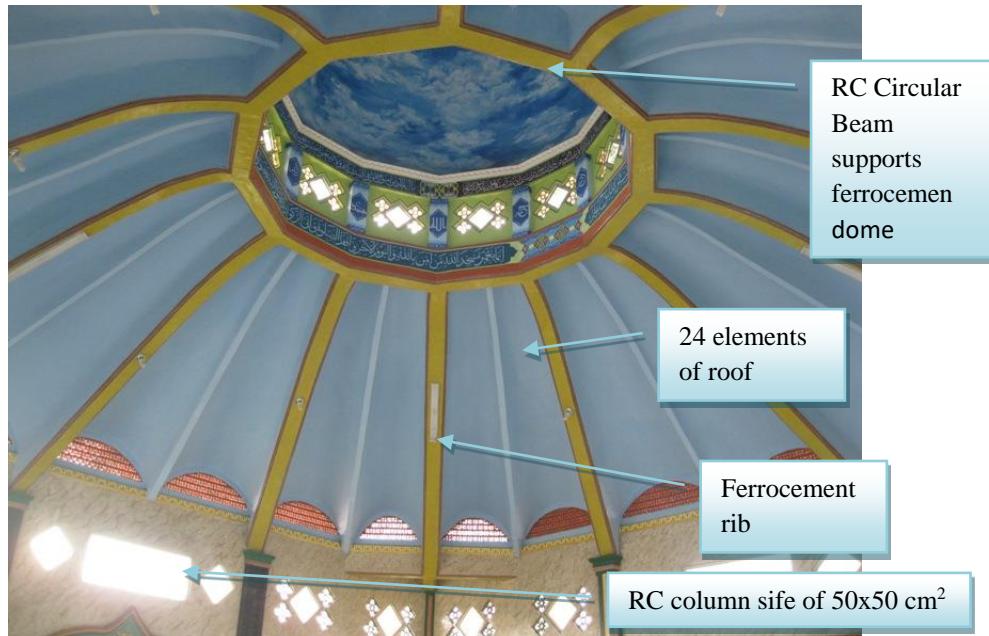


Figure 6. Ferrocement wave roof consists of 24 elements which supported by 12 oblique-angled RC beams.

In constructions stage, It was used mould at inside to make sure purposed shape and to speed up process of pastering the mortar. This was done because local labours did not have experiences yet to do pastering mortar from two sides, inside and outside.

## 2.2 Ferrocement Terrace Roof

Three sides of outside mosque are arounded by terrace which it's roof made of ferrocement with thickness same as others ferrocement elements. This shape is prominent if it is seen from outside of mosque and look beautiful and matching with others ferrocement constructions.



Figure 7. Appication of ferrocement on terrace roofs from outside.

Figure 7 & 8 shows the shape of ferrocement terrace roof from inside. Shape of its application looks like basin box as can be seen from illustration lines. Although the thickness is only 30 mm the structure has capability in sustaining compression force from vertical load through its shape.

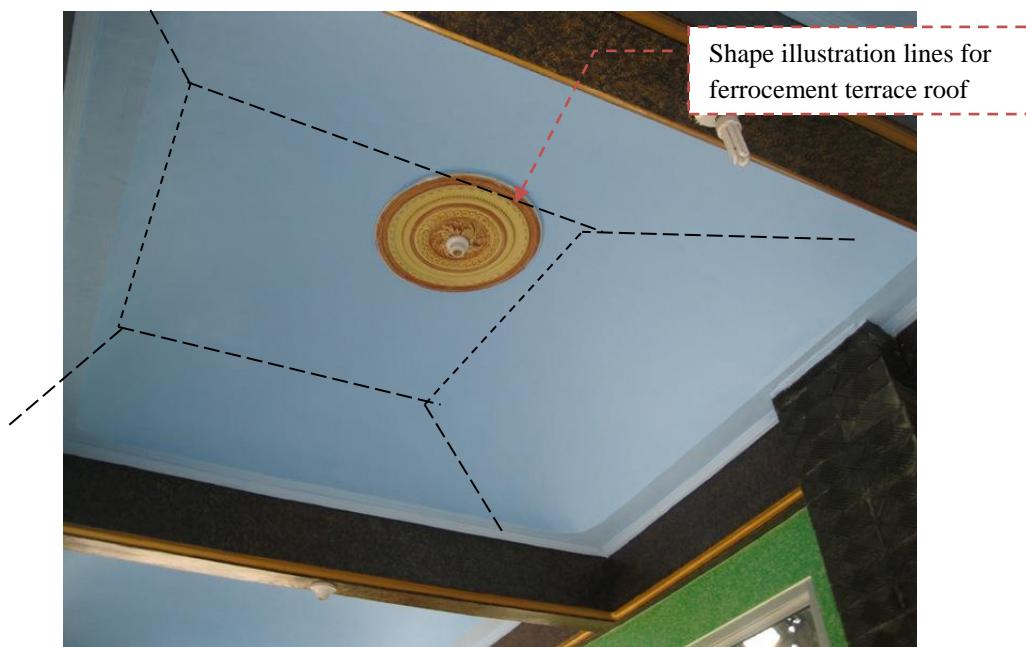


Figure 8. Appication of ferrocement on terrace roofs from inside.

### **3. CONCLUSIONS**

From description mentioned previously, it can be drown some conclusions as follows:

- a. Ferrocement can replace reinforced concrete structure especially in sustaining not too big load and for long span by modifying its shape adjusting to typically load applied. It can be seen at ferrocement application on wave shell roofs and terrace shell roofs.
- b. Construction of ferrocement elements such as dome, and wave shell roof can be done easily by local labours who have been trained in site at short time period.
- c. Design of ferrocement dome and wave shell roof can remove columns at middle of mosque therefore praying room becomes wider.
- d. Construction of ferrocement roof and dome can decrease self weight of structure almost 50% compared with reinforced concrete at the same applications.