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

Ferrocement an Appropriate and Sustainable Technology for under Development Countries

Editores
Hugo Wainshtok Rivas
Lázaro Prada Seoane
Iria Granda Castro

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Disasters, Durability and Others

Prólogo

Ferrocemento 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.

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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.

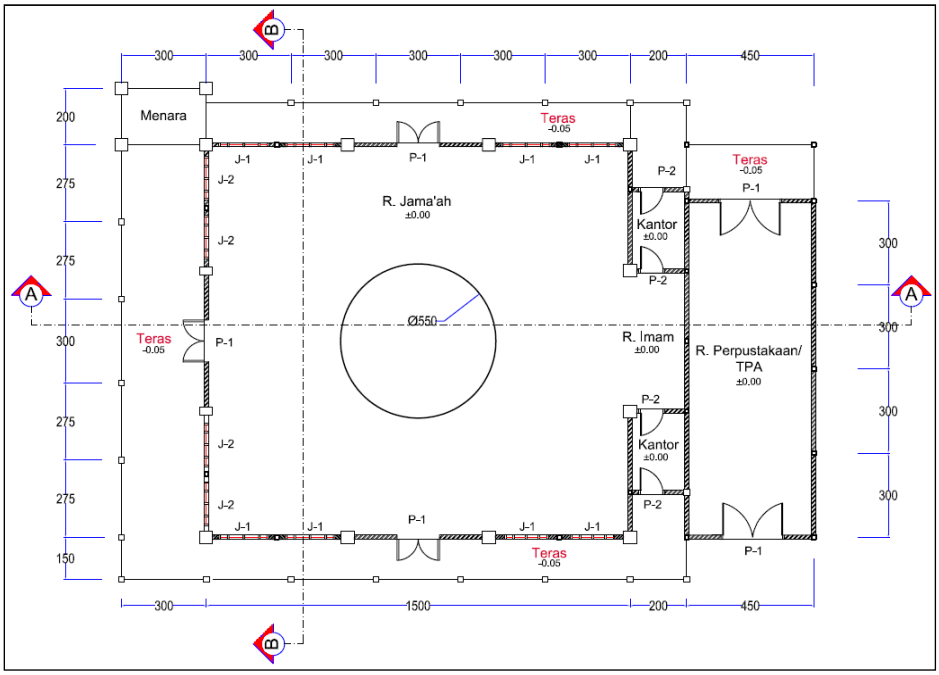

Figure 2. A new mosque ground plan.

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 surroudings 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.

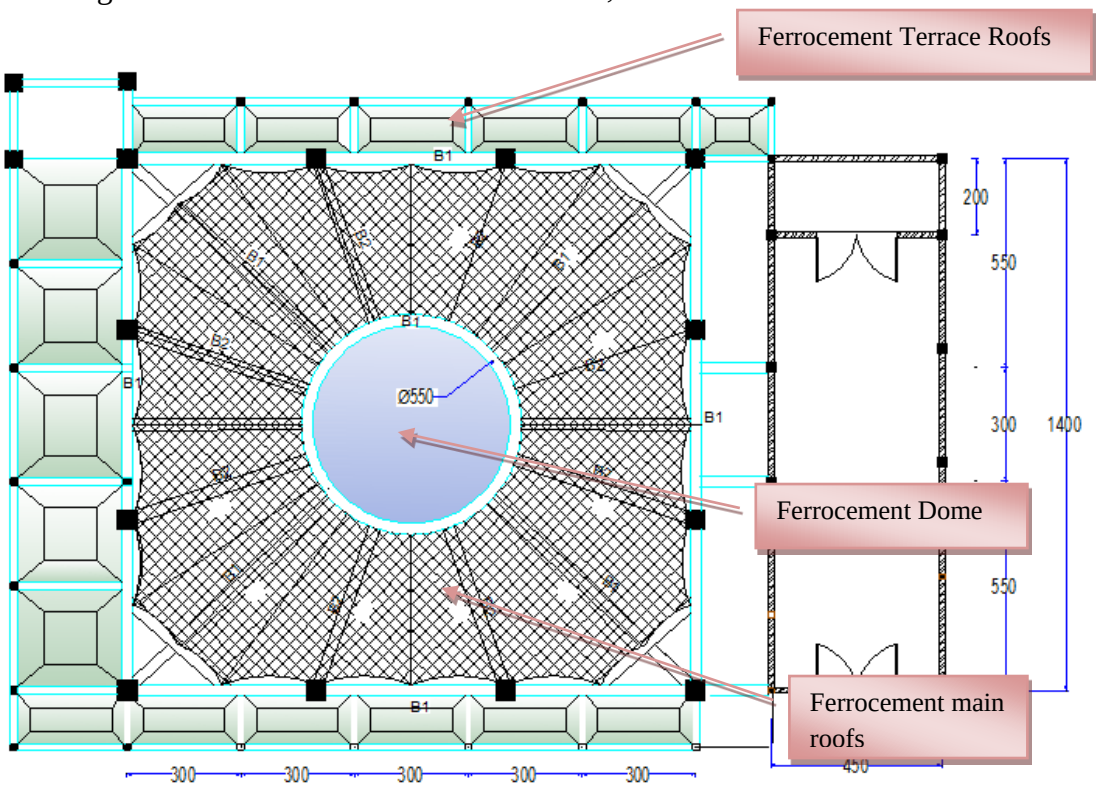

Figure 4. Sketch of Ferrocement dome and roofs.

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).

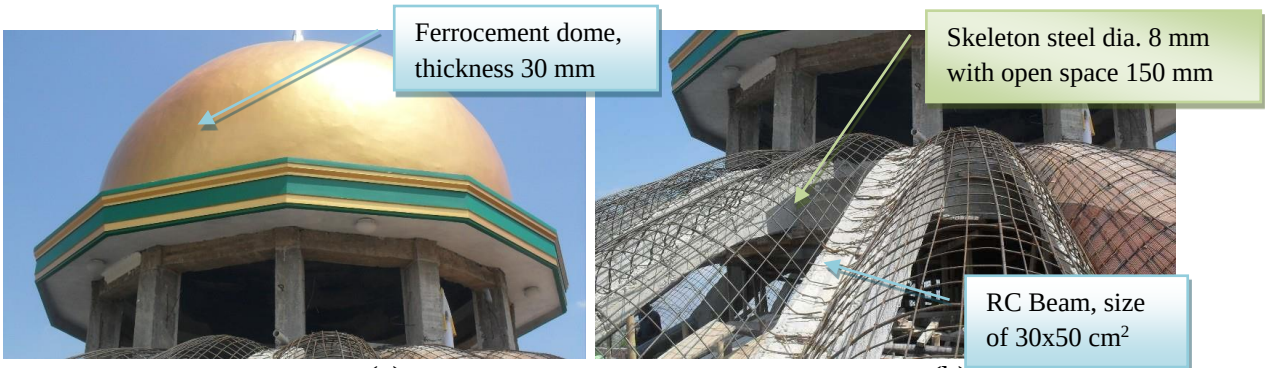

Figure 5. (a) Ferrocement Dome; (b) Reinforcement of Ferrocement wave roofs.

To cover main roof of the mosque was chosen wave shape with radius bigger at botton 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 thickenss 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.

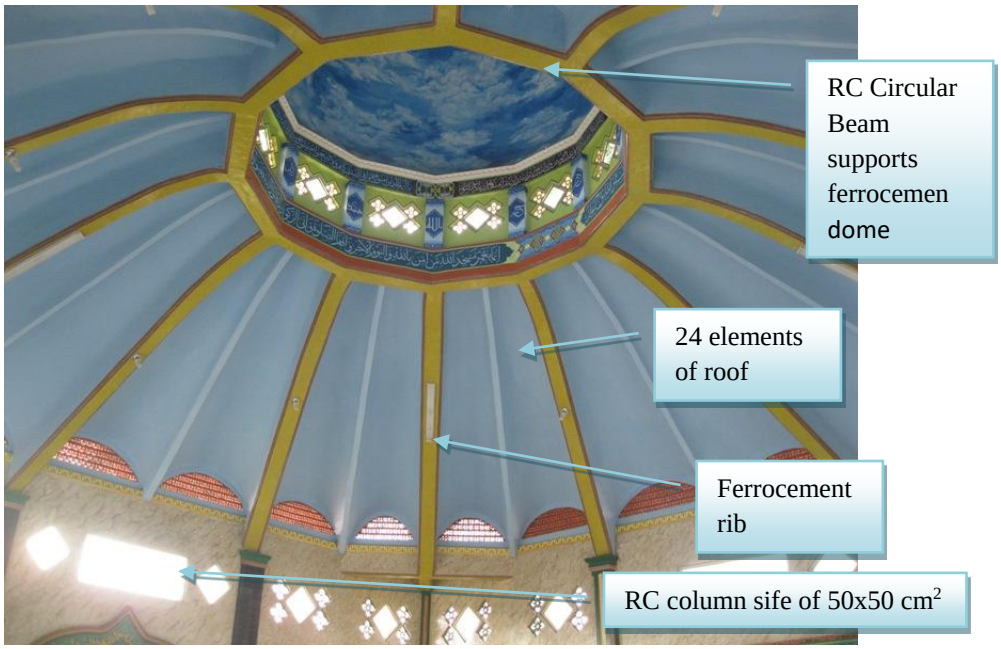

Figure 6. Ferrocement wave roof consits of 24 elements which supported by 12 oblique-angled RC beams.

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 macthing 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.

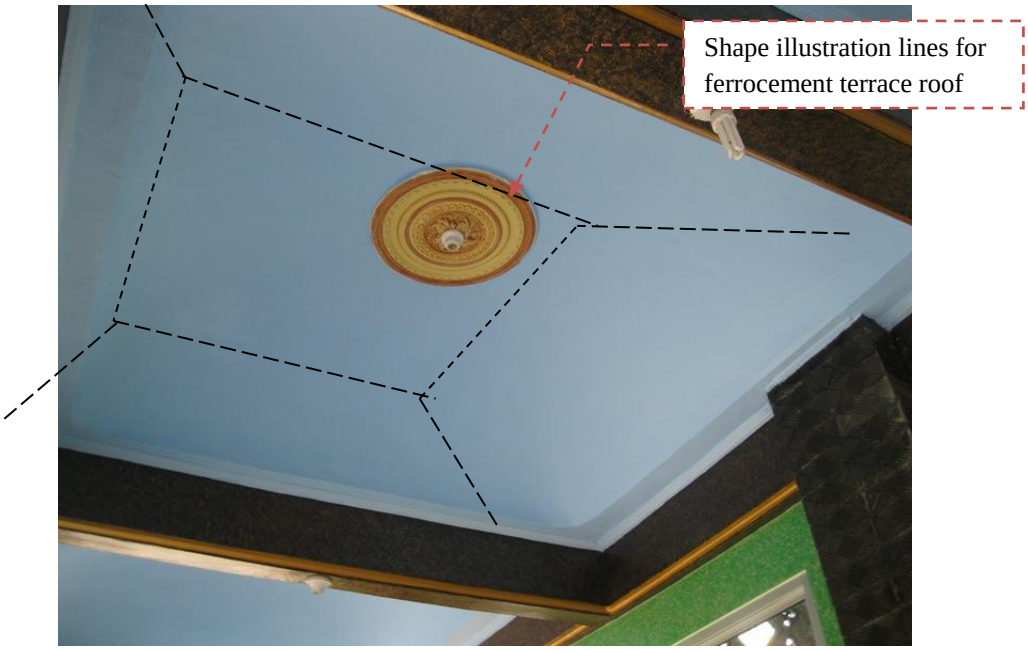

Figure 8. Appication of ferrocement on terrace roofs from inside.

3. CONCLUSIONS

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

a. Ferrocement can replace reinforced concrete structure espesially in sustaining not too big load and for long span by modifying its shape adjusting to tippically 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 easly 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.