Effect of shear connectors on strength of structural sandwich panels

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Abstract

This study investigates the structural behavior of precast lightweight sandwich panels with dimensions of (500 × 500 mm) and 120 mm height. Specimens consists of three layers: concrete face wythes (with thicknesses of 45 mm and grades of (80, 70) MPa) and high-density foam (with thickness of 30 mm) as a core material. Steel and carbon fiber shear connectors (rods and strips) were used in panels with angles of (45°, 60° and 90°). Three-point flexure load test was carried out on all panels. Obtained results were studied with predicted ultimate loads from ANSYS software and the theoretical extremes capacities of 0% and full-composite cases to evaluate the effects of changing components. Strength/weight ratio and degree of composite action were obtained to can judge the panels with effective parameter. It was found that adding carbon fiber strips has a high positive effect in degree of composite action. Steel bars shear connectors were the optimum shear connectors' type with high strength concrete. Carbon fiber strips and rods shear connectors were the best shear connectors' type with light high strength concrete. All properties of specimens enhanced with the decrease of the angle of shear connectors with both of steel and carbon fiber shear connectors. Angle of 45° is the optimum angle that resists the flexure load, obtaining high degree of composite action and high strength/weight ratio. It also obtained the highest percent of predicted ultimate loads from ANSYS software.

Keywords Precast concrete sandwich panel · Light-weight units · Shear connector · Carbon fiber · Light-weight concrete · Strength/weight · Composite · Shear flow

Abbreviations

FCR	Carbon fiber rods with diameter of 12 mm
FCS	Carbon fiber strips with cross section of (50 mm) × (1.2 mm)
HD foam	High density foam
HSC	High strength concrete
LHSC	Light high strength concrete

1 Introduction

Structural precast sandwich panel is defined simply as a composite section that consists of two reinforced concrete face wythes (upper and lower layers) and the insulation core layer between them. Structural sandwich panel section has many advantages such as: light weight (compared

to full concrete section), high ability of heat insulation and elimination of the need of heavy transportation and site construction equipment (comparing to precast concrete parts) [1, 2]. The technique behind sandwiched construction is to have the facings and core as a very efficient structural element together [3]. The precast foamed concrete sandwich panels slab has been found to act as an alternative to the conventional concrete slab system in buildings [4]. The sandwich structures can be compared to that of I-sections, through which the facings of a sandwich panel can be compared to the flanges of an I-beam, because they carry the bending, stresses [5]. Shear connectors represent an important part of composite beam design. An effective connector provides adequate shear strength between the steel beam and concrete for full composite action [6, 7]. The core corresponds to the web

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of the I-beam, as it resists the shear loads and stabilizes the faces against wrinkling or buckling. The core must be stiff enough to ensure that the facings remain separated by a proper distance. When the sandwich panel is bent, the core must also provide adequate shearing strength so that the facings will not slide relative to each other [6, 8]. In the inadequacy of necessary shear strength, the two thin facings would act as two independent beams or panels, and lose the sandwich effect [4]. Typical failure occurred when the specimens tested reached their ultimate load due to major cracks that extended significantly along the bottom concrete wythe, particularly at the mid-span [3]. In both monotonic loading and cyclic loading tests, the adhesive bonds based on the isolation absorption and the mechanical bonds base depend on the isolation surface roughness and groove treatment were effective in inducing the desired composite behavior of insulated concrete sandwich wall panels. To estimate the structural strength of insulated concrete sandwich, wall panels with glass fibers reinforced polymer shear sheets, the adhesive and mechanical bonds between the insulation and concrete wythes can be used [9, 10]. In L-shaped angle connectors the maximum stress occurs in the weld attachment to the beam, whereas in the C-shaped angle connectors [11, 12]. By using glass fiber reinforced polymer grids as shear connectors, it is possible to achieve both structural protection and superior reduction of heat loss properties. It was found that continuous shear connector type could provide better performance compared to a shear connector style stud. The structural performance of glass fiber reinforced polymer should be equal to that of conventional materials such as carbon steel [7, 13]. The polymer coating stopped the sandwich layers from wrinkling and buckling the fiber-composite skins. In the same direction, indentation failure for vertically layered beams in the phenolic core was removed. It also recorded less slip behavior in concrete under the square hollow connector compared with the circular and rectangular hollow steel tube connectors in both concrete strengths, and less compressive failure mode. In comparison to the smaller dimension, the rectangular hollow steel tube shows a 20% higher shear resistance, with a longer width in the direction of load. An analytical method has been proposed and predicts the shear resistance of hollow steel tube shear connectors with a standard deviation of 0.14 considering connectors shape and size of the connectors [10, 14]. In shear strength, full height stiffener increased between 157% and 233% and half height stiffener increased in shear strength between 45% and 150% under monotonous loading [13]. It was found that the polymer coating prevented sandwich layers from wrinkling and buckling the fiber-composite skins. Similarly, it eliminated indentation failure for vertically layered beams in the phenolic core [15]. In the four-point bending tests, the

high-performance sandwich panels extended polystyrene cores, or strengthened ultra-high-performance concrete face sheets combined with adhesive mortar, exhibited peak strengths higher than the other models, and failed stably, without delamination [16]. The proposed model for predicting the deflection of hybrid sandwich panels has been found to have equal agreement with the experimental values [15]. Previously, Adaptive Neuro Fuzzy Inference was used to classify the prevailing parameters affecting the shear strength forecast for angle shear connectors developed in C and L [17]. The use of channel shear connectors embedded in lightweight concrete in composite structures and shows that lightweight concrete has a minor effect on the specimens' ductility and load displacement performance [2, 18]. The shear transfer capacity of a precast concrete sandwich panel system consists of two prefabricated reinforced concrete wythes separated by a layer of wythe is influenced by the composite behavior/action degree [19]. It was verified that using lower mesh size however does not substantially increase the panel's total flexural load carrying capacity like rebars [1, 8]. In addition, it was found that for or all inclined angle shear connectors, higher connector size results higher efficiency due to higher thickness [12, 16]. Basalt fiber reinforced polymers effectively served as a shear connector and longitudinal reinforcement. The panels reinforced with Basalt fiber polymers showed a distinct load Plateau after connector failure occurred, which gave warnings of failure over excessive deflections usually used to warn of failure in parts strengthened with FRP [18, 21]. An appropriate estimation of channel shear connectors shear capacity at varying slip, web and thickness flanges, weight, and concrete compression strength [20]. The floating concrete stud improved composite action by stepping the central portion of the connectors and thus the amount of shear deformation between the wythes of the connectors [14, 21]. The use of precast concrete sandwich panels for flat plate and flat slabs appears to be promising future [5].

2 Experimental procedure

A total of 10 specimens were prepared in the experimental program. The size of all specimens 500 × 500 mm with overall height of 120 two grades of concrete (80.30, 70.40) MPa with constant thickness of 45 mm were used to produce outer face wythes. High-density foam was used as a core layer with thickness of 30 mm. Each specimen consists of face wythe reinforcement by steel of diameter = 6 mm/m length in both directions and 16 piece of shear connectors three types of shear connectors were used (steel, carbon fiber rods and carbon fiber strips). Shear connectors were installed in specimens

with three angles (45°, 60° and 90°). The total components of each specimen are shown in the Table 1. Figure 1 shows the sequence of preparing specimens. Figure 2 shows the distribution of shear connectors in one panel. Figure 3 shows the cross section for one specimen. The specimens were cured after casting for 28 days then specimens were tested under flexural load by three-point loading system as shown in Fig. 4. The weight after air during of each specimen was obtained with calibrated weight-scale to get strength/weight for each specimen. The results and strength/weight are shown in Tables 6 and 7. Cubes for each grade of concrete were prepared to get characteristic strength and density for

each grade. Characteristic strength and density for each grade are shown in Table 4.

2.1 Materials

Ordinary Portland cement (OPC) CEMI 42.5N, silica fume and quartz powder were used in production of concrete wythes. The specific gravities of the materials are listed in Table 2. A polycarboxylic ether based superplasticizer complying with ASTM C494 (Type G) was used. The density of high-density foam is 36 kg/m³. The chemical analysis of cement and silica fume and quartz powder is shown in Table 3. River sand and dolomite coarse aggregates were

Table 1 Table of components of specimens

No.	Concrete face wythes		Core		Shear connector	
	Type	T (mm)	Type	T (mm)	Type, dimensions (mm)	Angle (°)
1	HSC (high strength concrete)	45	HD foam (high density foam)	30	Steel rods $\Phi = 12$	45
2	HSC (high strength concrete)	45	HD foam (high density foam)	30	CFR (Carbon fiber rods) $\Phi = 12$	45
3	HSC (high strength concrete)	45	HD foam (high density foam)	30	CFS (Carbon fiber strips) Cross section = 50 × 1.2	45
4	LHSC (light high strength concrete)	45	HD foam (high density foam)	30	Steel rods $\Phi = 12$	45
5	LHSC (light high strength concrete)	45	HD foam (high density foam)	30	CFR (Carbon fiber rods) $\Phi = 12$	45
6	LHSC (light high strength concrete)	45	HD foam (high density foam)	30	CFS (Carbon fiber strips) Cross section = 50 × 1.2	45
7	LHSC (light high strength concrete)	45	HD foam (high density foam)	30	Steel rods $\Phi = 12$	60
8	LHSC (light high strength concrete)	45	HD foam (high density foam)	30	CFR (Carbon fiber rods) $\Phi = 12$	60
9	LHSC (light high strength concrete)	45	HD foam (high density foam)	30	Steel rods $\Phi = 12$	90
10	LHSC (light high strength concrete)	45	HD foam (high density foam)	30	CFR (Carbon fiber rods) $\Phi = 12$	90

Fig. 1 The sequence of preparing panels

Fig. 2 The distribution of shear connectors

used. The ingredients of two grades of concrete are listed in Table 4. Three types of shear connectors were used: Steel with diameter of 12 mm, Carbon fiber rods with diameter 12 mm carbon fiber strips with cross section of 50 mm × 1.20 mm. The characteristics of steel and carbon fiber are summarized in Table 5.

3 Analytical investigation

Theoretical capacities of specimens in ultimate stage were calculated manually in two extreme states for each specimen; the theoretical fully composite state and the non-composite state. Fully composite state occurs when the specimen behaves as solid slab with total thickness of 120 mm. Non-composite state was obtained when each concrete wythe behaves alone. The main role of shear connectors is transferring shear between concrete wythes. Changing variables causes occurring of composite action with different degrees. The theoretical extreme capacities

Fig. 4 The flexural load test

Table 2 The specific gravity of the materials

Material	Specific gravity
Sand	2.66
Cement	3.15
Dolomite	2.60
Quartz powder	2.70
Silica fume	2.15
Superplasticizer	1.15

in both states (non and fully composite) are shown in Table 6 according to the study of Benayoune et al. [4].

4 Numerical simulation

The predictions of failure capacities were obtained from ANSYS 18.2 software. Mesh properties were adaptive size function with the element size of 95 mm and with the coarse relevance enter with minimum edge length of 18.85 mm as shown in Fig. 5. Materials were defined in engineering data was concrete (with edited density and compressive strength of each concrete type) and steel

Fig. 3 The cross section for one specimen

Table 3 The chemical analysis of cement, silica fume and quartz powder

	OPC	Silica fume	Quartz powder
SiO ₂ , %	21.58	96.02	0.97
Al ₂ O ₃ , %	4.94	1.01	0.83
CaO, %	61.09	–	1.02
MgO, %	1.65	0.18	0.21
SO ₃ , %	3.22	0.26	0.33
Na ₂ O, %	0.50	0.14	0.05
K ₂ O, %	0.18	0.35	0.22
Fe ₂ O ₃ , %	3.56	0.52	0.35
Cl ₂ , %	–	0.16	0.05
Loss of ignition, %	2.60	–	–

Table 4 The ingredients of the two grades of concrete

	HSC (high strength concrete)	LHSC (light high strength concrete)
Characteristic strength (MPa)	80.30	70.40
Density (kg/m ³)	2660	2440
Cement (kg/m ³)	450	950
Sand	115	66
% of cementitious		
Dolomite	300	0
% of cementitious		
Quartz powder	0	23
% of cementitious		
Silica fume	0	30
% of cement		
Superplasticizer	2	3.80
% of cementitious		
Water	19	17.20
% of cementitious		

(with fatigue data at zero mean stress comes from 1998 ASME BPV code, section 8, Div2 table 5-11-1. Then the model was solved with the software to get the ultimate load. The ultimate loads obtained from the software were

compared with the experimental ultimate loads. The predicted overall ultimate failure loads from the software are shown in Table 6.

5 Results

Experimental results are included in Table 6. Also Table 7 shows the degree of composite (%), weight and (strength/weight) ratio. The results of degree of composite action in this study were in the same range of some related previous studies. The comparison is illustrated in Table 8. The failure shape in experiments and ANSYS software are shown in Figs. 6 and 7, respectively. It is noticed that the experimental failure shape is similar to the predicted one from ANSYS software.

6 Discussion

Structural lightweight precast sandwich panels were used worldwide latest decade [21, 22]. It can provide the optimum solution between weight, heat insulation, and strength. Its efficiency depends on the degree of composite action achieved by structural behavior in case of loading. Shear connectors should be taken in consideration because they play the main role in shear flow between face wythes. Shear connectors material and positions control also the degree of composite action. The great advantage of carbon fiber shear connectors is light weight than steel others and insulation role between two concrete wythes therefore the steel shear connectors works as thermal bridges between two wythes. It is highly desired to find the optimum shear connector material and position. The main cause of replacing steel with carbon fiber is: the high thermal conductivity of steel that make it work as thermal bridge between concrete face wythes. That effect inconsistencies with the function of heat insulation of sandwich panels. The second reason of replacing steel with carbon fiber

Table 5 The characteristics of steel and carbon fiber shear connectors

	Steel bars	Carbon fiber rods	Carbon fiber strips
Dimensions (mm)	Bars with diameter of 12	Bars with diameter of 12	Strips with cross section of 50 × 1.20
Laminate tensile strength (kN/mm ²)	0.80	3.10	3.10
Fibre volume content	–	>65%	>68%
Laminate elongation at break (%)	15	1.75	1.80
Glass transition temperature	–	>100°	>100°
Laminate modulus of elasticity	200 GPa	148 kN/mm ²	170 kN/mm ²
Cross sectional area (mm ²)	113	113	60

Table 6 The results of experiments, ANSYS and theoretical extremes

No.	ANSYS failure load (kN)	Actual failure load (kN)	Theoretical non composite load (kN) 0% composite	Theoretical fully composite load (kN) 100% composite
1	85.32	76.63	31.95	90.04
2	80.27	67.59	31.95	90.04
3	89.57	79.50	31.95	90.04
4	81.06	61.78	31.64	89.88
5	77.65	63.81	31.64	89.88
6	85.30	68.34	31.64	89.88
7	72.51	47.40	31.64	89.88
8	76.78	60.73	31.64	89.88
9	60.57	40.90	31.64	89.88
10	65.26	51.60	31.64	89.88

Fig. 5 Mesh of specimen in ANSYS 18.2 software**Table 7** The degree of composite (%), weight (kg) and (strength/weight) ratio (kN/kg)

No.	Degree of composite (%)	Weight (kg)	Strength/weight (kN/kg)
1	85.11	65.30	1.17
2	75.07	63.16	1.07
3	88.29	62.78	1.27
4	68.74	60.35	1.02
5	70.99	58.21	1.10
6	76.03	57.83	1.18
7	52.74	59.87	0.79
8	67.57	58.11	1.05
9	45.51	59.56	0.69
10	57.41	58.05	0.89

is the very lightweight of carbon fiber material comparing to steel. By the way, the weight of shear connectors affects overall weight of panel and strength/weight ratio.

Table 8 Comparison between the results in this study and some related previous studies

Type of shear connector	Range of (degree of composite action %) in results	From
Steel	68–85	Results in this study
Steel	64–95	Ref. 3.[4]
Steel	61–96	Ref. [1]

In this study: it was aimed to obtain high degree of composite action and high percent of (strength/weight) ratio by increasing strength of slabs with lighter weight of slabs, approaching fully-composite action as possible by choosing the optimum type of shear connectors and angle of them. The ultimate loads obtained from experimental three-point bending test were compared with the theoretical extreme capacities for each slab (100% degree of composite and 0% degree of composite) and predicted ultimate load from ANSYS software. Degree of composite action (%) was obtained of each specimen to determine which parameter affects degree of composite. Strength/weight ratio of each panel was calculate to make effective parameter between strength and weight that can judge specimens.

1. Effect of changing material of shear connectors with high strength concrete (grade of 80.30 MPa and density of 2660 kg/m³)

When comparing the materials of shear connectors, shear connectors are installed in the specimens with angle of 45°. Face wythes consist of high strength concrete (grade of 70.40 MPa and density of 2440 kg/m³) and core wythe consists of high density foam. Specimens 01, 02 and 03 obtained about 90%, 84% and 88% of the predicted ultimate loads from ANSYS software respectively. When material of connectors changed from steel to carbon fiber rods, the ultimate load decreased by 11.70%. In addition, it increased by 3.70% when the material changed from steel to carbon fiber strips. The highest degree of composite action was with carbon strips by 88.29%. That high percent may be because of wide cross section which facilitated shear transfer between face wythes. Degree of composite in specimens 01 and 02 was 85.11% and 7.07% respectively. By the way, the biggest strength/weight ratio is that of specimen 03 with carbon strips and it was about 1.27 kN/kg. It decreased by 7.80 and with 15.70% when carbon fiber strips changed to steel and carbon fiber rods respectively. That because of the very light weight of carbon fiber strips. The thermal conductivities of the composite systems in this part are 1.39, 0.61 and 0.17 W/m·C° for the specimens 01, 02

Fig. 6 Failure at experiment

Fig. 7 Failure in ANSYS 18.2 software

Fig. 9 Shear connectors' material effect on strength/weight and degree of composite with HSC

Fig. 8 Shear connector material effect on ultimate capacity with HSC

and 03 respectively. That high variance between values evidences the great insulation role of the carbon fiber materials in specimens. Figures 8 and 9 show the histograms of previous discussion.

- Effect of changing material of shear connectors with light high strength concrete (grade of 70.4 MPa and density of 2440 kg/m³)

When comparing the materials of shear connectors, shear connectors are installed in the specimens with

angle of 45°. Face wythes consist of light high strength concrete (grade of 70.40 MPa and density of 2440 kg/m³) and core wythe consists of high-density foam. Specimens 04, 05 and 06 obtained about 76.21%, 82.17% and 80.11% of the predicted ultimate loads from ANSYS software respectively. When material of connectors changed from steel to carbon fiber rods, the ultimate load increased by 3.20%. Moreover, it increased by 10.6% when the material changed from steel to carbon fiber strips. The highest degree of composite action was with carbon strips by 76.03%. That high percent may be because of wide cross section which facilitated shear transfer between face wythes. Degree of composite in specimens 04 and 05 was 68.74% and 70.99% respectively. By the way, the biggest strength/weight ratio is that of specimen 06 with carbon strips and it was about 1.18 kN/kg. It decreased by 13.50% and with 6.70% when carbon fiber strips changed to steel and carbon fiber rods respectively. That because of the very lightweight of carbon fiber strips. The thermal conductivities of the composite systems in this part are 1.30, 0.60 and 0.16 W/m·C° for the specimens 04, 05 and 06 respectively. That high

Fig. 10 Shear connectors' material effect on ultimate capacity with LHSC

Fig. 12 Shear connectors' angle effect on ultimate loads with steel shear connectors

Fig. 11 Shear connectors' material effect on strength/weight and degree of composite with LHSC

Fig. 13 Shear connectors' angle effect on strength/weight and degree of composite with steel shear connectors

variance between values evidences the great insulation role of the carbon fiber materials in specimens. Figures 10 and 11 shows the histograms of previous discussion.

- Effect of changing angle of shear connectors with light high strength concrete (grade of 70.4 MPa and density of 2440 kg/m³) and steel bars shear connectors

When comparing the angle of shear connectors, light high strength concrete (grade of 70.40 MPa and density of 2440 kg/m³) was used in specimens. In this part the steel bars shear connectors were used. The three angles 45°, 60° and 90° were tested in the three specimens 04, 07 and 09 respectively. The three specimens 04, 07 and 09 obtained 76.21%, 65.37% and 67.52% of the predicted ultimate loads from ANSYS software respectively. The highest ultimate load was that of specimen 04 with angle of 45° by 61.78 kN. The ultimate load decreased by 23.27% and 33.79% when angle changed from 45° to 60° and 90° respectively. The bigger value of degree of composite action was that of specimen 04 by 68.74% then specimen 07 by 52.85% then specimen 09 with 45.51%. Specimen 04 obtained the highest strength/weight ratio by 1.02

kN/kg and it decreased by 23% and 32% when angle changed to 60° and 90° respectively. Figures 12 and 13 show tests results of this part. The thermal conductivities of the composite systems in this part are 1.30 W/m·C° for the three panels. Therefore, it can be concluded that the changing of the shear connectors' angle has no effect on thermal conductivity. In general, results relieved that the optimum angle to be used in precast sandwich panel is that of 45°.

- Effect of changing angle of shear connectors with light high strength concrete (grade of 70.4 MPa and density of 2440 kg/m³) and carbon fiber rods shear connectors

When comparing the angle of shear connectors, light high strength concrete (grade of 70.40 MPa and density of 2440 kg/m³) was used in specimens. In this part, the carbon fiber rods shear connectors were used. The three angles 45°, 60° and 90° were tested in the three specimens 05, 08 and 10 respectively. The three specimens 05, 08 and 10 obtained 82.17%, 79% and 79% of the predicted ultimate loads from ANSYS software respectively. The highest ultimate load was that of specimen 05 with angle of 45° by 63.81 kN. The ultimate load decreased by 4.80% and 12.12% when

angle changed from 45° to 60° and 90° respectively. The bigger value of degree of composite action was that of specimen 05 by 70.99% then specimen 08 by 67.57% then specimen 10 with 57.41%. Specimen 05 obtained the highest strength/weight ratio by 1.10 kN/kg and it decreased by 4.5% and 19% when angle changed to 60° and 90° respectively. Figures 14 and 15 shows tests results of this part. The thermal conductivities of the composite systems in this part are 1.16 W/m·C° for the three panels. Therefore, it is possible to say that the changing of the shear connectors' angle has no effect on thermal conductivity. In general, it can be concluded that the best angle to be used in precast sandwich panel is that of 45°.

6.1 Analysis with SPSS software

Experimental results were inserted to SPSS software program to get correlation and determine significantly for each parameter (material of shear connectors and angle of shear connectors). Analysis type was multi dunken with separated parameters. Results were shown in Table 9.

7 Conclusions

Based on the results of this experimental investigation under tidal environment, the following conclusions are drawn:

Adding carbon fiber strips in specimen as shear connectors has a high positive effect in degree of composite action in specimen 03 comparing to the similar panels with different type of shear connectors. Furthermore, the specimens contain carbon strips obtained high percent from predicted ultimate loads from ANSYS software. The great advantage of carbon fiber shear connectors is that high relevant lightweight than steel others and the

Fig. 14 Shear connectors' angle effect on ultimate loads with carbon fiber connectors

Fig. 15 Shear connectors' angle effect on strength/weight and degree of composite with carbon fiber connectors

insulation role between two concrete wythes comparing to the steel shear connectors that works as thermal bridges between the two concrete wythes.

On the other side, using steel bars as shear connectors was the best shear connectors' type with high strength concrete. However, it was noticed that using carbon fiber strips and rods as shear connectors was the best choice of shear connectors' type with light high strength concrete. That was illustrated in the results of degree of composite, strength/weight ratio and overall ultimate strength.

It can be concluded that using steel shear connectors with angle of 45° is better than using carbon fiber rods and strips with same angle with the two types of concrete. However, using carbon fiber rods and strips with angles of 60° and 90° is better than using steel shear connectors with same angle with the two types of concrete. By the way, structural behavior of slabs enhanced with the decrease of shear connectors installing angle from 90° to 60° then 45° with steel and carbon fiber shear connectors. So it can be concluded that angle of 45° is the optimum angle to be used in ultimate load, degree of composite action and strength/weight ratio. It also obtained the highest percent of predicted ultimate loads from ANSYS software.

Analysis with SPSS software program showed that all parameters correlations in this thesis were significant.

Table 9 SPSS software results

Parameter	No. of specimens	Correlation	Level
Type of shear connector	1, 2, 3	Significant	0.05 (2-tailed)
	4, 5, 6	Significant	0.01 (2-tailed)
Angle of shear connector	4, 7, 9	Significant	0.01 (2-tailed)
	5, 8, 10	Significant	0.01 (2-tailed)

8 Future recommendations

It is recommended to use carbon fiber strips with more lightweight concrete. In addition, it is desirable to prepare specimens with thinner thicknesses of concrete wythes and efforts should be made to find out the optimum thickness that balanced between high strength, heat isolation and light weight.

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Conflict of interest The authors declare that they have no conflict of interest.

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