Hybrid Composite Beam (HCB)

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Abstract: Nowadays civil engineering is more concerned with substituting old traditional ways of construction with modern ones. The main objectives are saving effort, money, time…etc. Modern civil engineering has concentrated on solving and facilitating our daily events such as transportation costs and facilitates movement of the beams at the construction sites . To solve this problem, civil engineers considered steel to be the main material in bridge construction, which have a high weight to strength ratio. so the idea of composite material of steel and concrete was suggested to replace the part of steel construction.. except the economic and construction time problems relative to all the construction materials used through the time, composite material is the most expensive and the most time consuming in construction, but has the ability for building very quickly and the availability of the main constituents of concrete Hybrid composite beam (HCB) has solved all the previous problems ..

In this paper, the Hybrid Composite Beam consisted of combination of concrete , steel and glass fiber-reinforced polymer in an efficient form, is studied as a simplified system to reduce the design requirements of construction of bridges instead of precast concrete beams and accomplishes both quick construction and increased durability. A comparison is to be made between HCB and Precast Concrete Beam in terms of time, transportation facilities and difficulties, and construction requirements. This study is supported by a stress analysis using SAP2000 showing the different response of both of them when subjected to different cases of loading.

Keywords: model validation, HCB

I. INTRODUCTION

In recent years, reactions of precast concrete on frames, columns, pile cap and piles have been a great deal in design of bridges. These reactions require larger section to withstand these loads which in turn waste material and money. HCB contribute in reducing these reactions resulting in smaller sections and lower cost due to its relative small weight to strength ratio. The HCB is composed of three main parts: shell, compression reinforcement and tension reinforcement.

the shell is comprised of a fiber reinforced plastic **(FRP)** box beam. The compression reinforcement consists of Portland cement concrete that is pumped into a profiled framework. The tension reinforcement consists of carbon, glass or steel fibers anchored at the ends of the compression reinforcement. the FRP materials gives greater corrosion resistance and longer life time. Due to its smaller weight, shipping and construction costs of HCB is lower than precast which acts as a great privilege. The weight of the composite beams during transportation and construction is approximately one fifth of the weight of the conventional steel beam required for the same span and approximately one tenth of the weight required for a precast prestressed concrete beam for the same span. In addition, HCB achieves serviceability requirement by providing additional strength more than that of required in the code which represent highest level of safety. The FRB is supported by using high durable material like glass fabrics, tension reinforcing, compression reinforcing, core materials and resins which provides higher flexibility and stress endurance. Consequently, it is clear that HCB is more economic than conventional precast concrete in specific cases. With respect to cost metrics, the main advantages of HCB appear significantly in longer spans in which the lightweight advantages of the hybrid-girder may result in the girder costs being less than for prestressed concrete beams. Components of the beam are arranged in a specific way that guarantees maximum workability of the beam. The behaviour of the two beams is relatively similar in which It either acts as a steel box beam or tied arch. In the end, the HCB can be built quickly and easily using the beam discussed above.

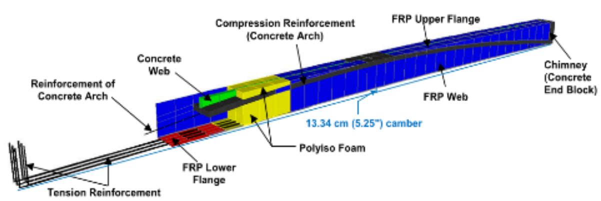


Fig. (1): Schematic diagram of Hybrid Composite Beam (HCB) structure.

II. MODEL VALIDATION

To prove all the previous studies, A SAP2000 analysis has been performed on both HCB and precast concrete by applying different cases of loading symmetrically and asymmetrically, concentrating the analysis mainly on the self-weight of the beam which is the distinct privilege of HCB. The experiments revealed that the reactions resulted from the HCB was much smaller than that resulted from precast concrete as well as the deflection so, the required sections for frames, columns, pile cap and piles, carrying HCBs are smaller than that of required for those carrying precast ones. In long spans, precast beam requires soil with great bearing capacity to safely carry the equipment used in construction, which in result offers sophisticated challenges. HCB overcomes this problem due to its lighter weight.

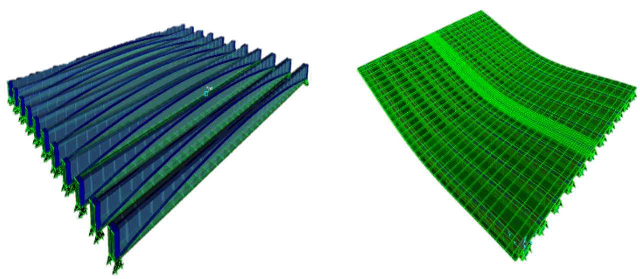


Fig. (2): *Structural analysis of HCB repeated bay by Sap2000 software*

Fig. (3): *Detail of interior and exterior engineering design of HCB composite structure.*

III. MODELLING OF HYBRID COMPOSITE BEAM

The different elements of HCB have been instrumented with strain gauges to measure the normal and
shear strains. The superstructure is modelled via the SAP2000. The analysis was made using the loads of the Egyptian code for designing bridges. These are HCB analysis from different views Figs. (1) to (3).

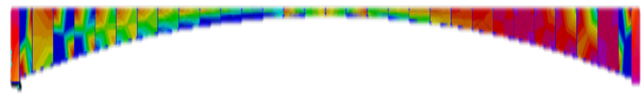


Fig. (1): *The resultant stresses analysis of HCB repeated bay by Sap2000 software*

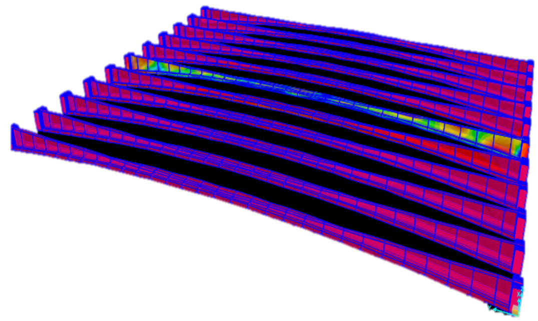


Fig. (2): *The resultant moment analysis of HCB repeated bay by Sap2000 software*

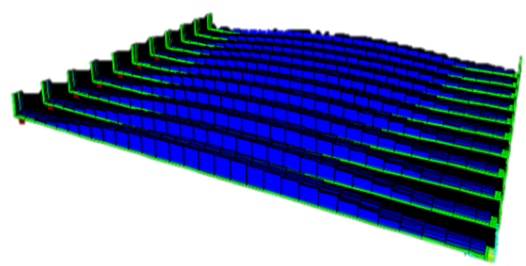
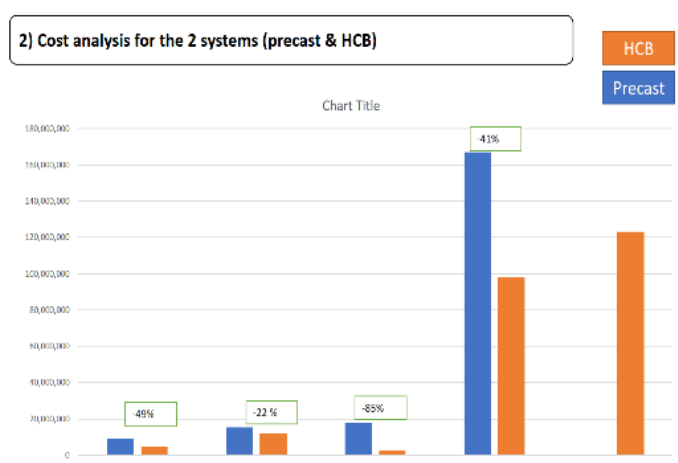


Fig. (3): *The resultant shear stress analysis of HCB repeated bay by Sap2000 software*



After completion of the SAP200 Analysis, the data were retrieved and post processed to evaluate the specific behavioral characteristics including lateral load distribution, internal/external load sharing behavior, and the moving loads. The interpreted data was then used to calculate the Bridge Dimensions and Reinforcement. The Figure (4) shows the resultant data after designing using Excel Sheet.

Design **REC.** Sec.

MU	511.7	m.t
depth (t) =	200	cm
cover =	20	cm
b web =	150	cm
ts =	0	cm
fcu =	450	Kg/Cm²
fy	4000	Kg/Cm²
Ec =	29516	N/mm²
diam. use =	32	mm

M	=	341.13	m.t
M_U	=	511.70	
B	=	150.00	cm
b web	=	150.00	cm
d	=	180.00	cm
fcu	=	450.00	Kg/Cm²
fy	=	4000.00	Kg/Cm²
C1	=	6.54	
j	=	0.85	
As	=	86.04	

J> .826 take j = 0.826

Check As min

As1	=	(11 / fy) X B X d =	74.25	Cm²
As2	=	1.3 X As req =	111.85	Cm²
As3	=	0.15 /100 X B X d =	40.50	Cm²

As min = 74.25 Cm²

As des = 86.040 Cm²

Φ	8	10	12	16	18	19	22	25	32
N/M	115	73	51	29	23	21	15	12	7
n	172	110	77	43	34	31	23	18	11

Fig. (4): *Design of frame, column, Pile & Pile cap by Excel Sheets (Made by Project group) according to ECP.*

IV. THE COMPARISON

To fulfill the assumption made in the beginning. That although HCB Constructions costs are larger than that of Precast Concrete Bridge, HCB saves a lot of time in construction which can in turn reduces the total cost of the project while calculating labor costs and indirect costs. Figure (5) & (6) shows a detailed comparison of the prices of each process in constructing a HCB and Precast Concrete Bridge.

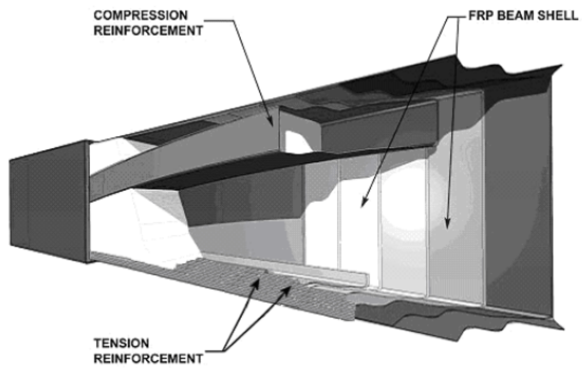
Savings	HCB	Precast	الوحدة	بيان الأعمال	م
0	577,800	577,800	[illegible]	[illegible]	1
0	220,006	220,006	م3	الحفر	2
0	22,260	22,260	م3	الردم	3
4,208,700	4,484,000	8,870,700	م.ط	خوازيق (ق100 سم precast / ق60 سم HCB)	4
80,400-	40,000	120,400	عدد	[illegible]	5
0	1,303,820	1,303,820	م3	خ ع لزوم الأساسات	6
0	2,084,150	2,084,150	م3	خ م لزوم الأساسات	7
0	894,568	894,568	م3	خ م لزوم الأعمدة	8
0	10,403,316	10,403,316	م3	خ م لزوم بلاطة الكوبري على الكمرات الغير محملة	9
0	755,766	755,766	م3	خ م لزوم بلاطة الكوبري على الكمرات [illegible]	10
3,377,700-	11,884,500	15,262,200	م3	خ م لزوم الكمرات (HCB / precast)	11
15,136,750	2,715,000	17,851,750	م3	خ م لزوم الكمرات (HCB / precast)	12
0	37,212,000	37,212,000	[illegible]	[illegible]	13
88,895,000	87,887,500	188,882,500	طن	حديد التسليح	14
0	1,248,940	1,248,940	م.ط	[illegible] 120 سم	15
0	848,800	848,800	م.ط	[illegible] 120 سم	16
0	52,710	52,710	م2	[illegible]	17
0	1,747,845	1,747,845	م.ط	[illegible] expansion joint	18
0	1,185,624	1,185,624	م.ط	فواصل حرارية Thermal Joint	19
663,600	2,433,200	1,769,600	[illegible]	[illegible]	20
0	149,800	149,800	[illegible]	[illegible]	21
0	107,000	107,000	[illegible]	[illegible]	22
0	159,500	159,500	[illegible]	[illegible]	23
0	256,000	256,000	م.ط	مواسير PVC [illegible]	24
123,200,000	123,200,000	0	م2	[illegible] (glass fiber & carbon fiber) [illegible]	25
32,159,050	301,534,913	269,375,863	الإجمالي		

Fig. (5)

Fig. (6)

V. CONCLUSION

This paper studied the structural behaviour of a new type of HCB that has been recently used in the construction of bridges. In conclusion, we have discussed the major problem we face in designing bridges. After the analysis made, we can conclude that the future of bridges is going to depend mainly on high developed ways of constructing which our topic HCB is on head of them. The main outcome of this study is that although some designing processes may seem to be more expensive, it can also save a lot of time which in turn can save indirect costs.



Final Beam Design

VI. REFERENCES

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