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Characteristic Study on Cable-Stayed and Extradosed Bridge

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Abstract*: This paper presents study of cable-stayed bridge and extradosed bridge. For analysis 100m, 150m, 200m, 250m and 300m spans are considered. Extradosed bridge is a novel idea bridge between Girder Bridge and cable-stayed bridge. This paper is concluded with study of various parameters of these types of bridges. The parametric study includes response of deck, deck moment, study of pylon, how the response of bridge varies span wise, from aesthetics point of view feasible bridge structure, pylon height and span length to thickness of girder ratio. The parameters of extradosed bridge are compared with cable-stayed bridge.

Keywords: CSI Bridge, cable-stayed bridge, extradosed bridge, bending moment, shear force, pylon height, girder depth, aesthetic view.

I. INTRODUCTION

During XIX century, one of the most relevant contributions to bridge engineering has been the introduction of prestressed technique, which is a solution to the need of controlling stress on elements in bridges. Initially this technique was employed by means of internal and external prestressed tendons, until 1925 when modern cable-stayed bridges appeared –the Tempul Aqueduct, which was developed and built by Eduardo Torroja (Torroja, 1927). In 1988 Jacques Mathivat proposes the concept of extradosed cables that are external prestressed tendons allocated in the deck's outer and upper side, which are diverted by low size masts (Mathivat, 1988) (Benjumea et al. 2010). Extradosed bridges are distinguished visually from cable-stayed bridges in their lower pylon height and hence shallow stay angles, larger girder stiffness in comparison to that of cable-stayed bridges.

II. LITERATURE REVIEW

Podolny (1961), has discussed the history, advantages, structural arrangement, and stay-cable spacing of concrete cable-stay bridges. As late as 1970, the practical span limit for steel cable-stayed structures was considered to be 1000 ft (300m). Currently, the Dame Point Bridge, concrete alternate, contemplates a 1300 ft (396m) main span. Concrete cable-stayed bridges with spans of 1600 ft (500m) are considered technically feasible. The concept of a concrete cable-stayed bridge has extended the practical and competitive economic span range to the extent that concrete is a viable material alternative in the long-span bridge range.

Supporting a beam or bridge by inclined cable stays is the concept used in cable-stayed bridge, the inclined cables of the cable-stay bridge support the bridge deck directly with relatively taut cables. Although the modern renaissance of cable-stayed bridges is said to have begun in 1955, with steel as the favoured material, in the last two decades a number of cable-stayed bridges have been constructed using a reinforced or prestressed concrete deck system. In recent years, several concrete cable-stayed bridges have been built in the long span range. Cable-stayed bridges have extended the competitive span range of concrete bridge construction to dimensions that had previously been considered impossible and reserved for structural steel. With technology of prefabrication, prestressing, and segmental cantilever construction, it is obvious that cable-stayed bridges are extending the competitive span range of concrete bridges to dimensions that had previously been considered impossible and in a range which had previously been the domain of structural steel. The technological means exist, they only require implementation.

Ikeda and Kasuga (2000), had studied the difference between extradosed and cable-stayed bridges in structural aspect showing some examples. Extradosed bridges, which have been brought up successfully in Japan, have to be clarified the differences from the ordinary cable-stayed bridges both in terms of structural characteristics and design specifications. They expect that the establishment of these specifications coupled with the successful completion of extradosed bridges will further contribute to the advancement of the extradosed bridges. N. Krishna Raju (2009), a revolutionary approach to bridge design and construction first conceived by the German Engineer Dischinger in 1938 and later put into practice in the construction of first modern cable stayed bridge is the Stromsund Bridge in Sweeden around 1953. This innovation paved the way for the construction of famous Rhine family cable stayed bridges with spans up to and exceeding 300m. According to Leonhardt, cable stayed bridges are technically, economically, aesthetically and aerodynamically superior to the classical suspension bridges for spans in range of 700 to 1500m. The combination of cable stays with cellular box girder prestressed concrete decks have significantly extended the span range of highway bridges. India's first cable stayed bridge is the Akkar Bridge in Sikkim completed in 1988 and extending over a length of 157 m with a single pylon height of 57.5 m.Benjumea et al. (2010), in this paper the historical context describing the origin of extradosed bridge, the influence of the principal structural elements and design proposed by researchers are presented. Extradosed bridge is generally recognized as an intermediate solution between cable-stayed bridges and cantilever constructed prestressed box-girder bridges because these take advantages of design and construction methods of the other two typologies. The concept of extradosed bridge goes back to 1988 with the proposal by the French Engineer Jacques Mathivat. However, the idea was not totally accepted in its origin continent. It was only adopted six years later when the first extradosed bridge was built in Japan. Ever since and because different worldwide well-known bridge engineers, among them Akio Kasuga and the prestigious Professor Christian Menn, chose this typology obtaining positive results, then extradosed bridges have become a competitive structural solution as well as prestressed box-girder bridges, for main spans between 100 and 200m. Structural behaviour in such bridges depends on the interaction among each structural element involved, therefore, provided that they share some morphological and constructive similarities with cable-stayed and prestressed box-girder bridges. Biliszczuk et al. (2017), they presented examples of short-, medium-, and long-span extradosed bridges designed and built in recent years in Poland. Paper represents some details of design and construction of selected extradosed bridges. They concluded this paper with geometrical parameters characterizing presented structures. The parameters were compared with values obtained for cable-stayed bridges and extradosed bridges built worldwide. The extradosed bridge structure developed since 1990s. The first such structure was the Odawara Blueway Bridge, designed and constructed in Japan (Shirono et al. 1993). The feature distinguishing the extradosed bridge form cable stayed bridge is the lower tower height above the deck and hence shallow stay angles. Another extradosed bridge feature is the larger girder stiffness compared to cable-stayed bridge. Stays in the extradosed bridges can be stressed to a relatively high level, similar to use in prestressed girder structures, since the stress variation under live loads in stays is usually lower in comparison with the cable-stayed bridges (Kasuga, 2006; Mermigas, 2008). The extradosed bridges, despite their relatively short history, have found their place among other bridge types and are more and more often designed and constructed. Cost wise they can be competitive in comparison to even 200-m long cable stayed bridges (Biliszczuk et al. 2016). Extradosed bridges can compete with beam and arch bridges; visually they are more attractive in comparison to cable-stayed and simple girder bridges.

III. SCOPE OF THE PAPER

In this paper, the behaviour is studied for both bridge decks (cable-stayed bridge and extradosed bridge) for various spans and 70R loading. The different deck models are prepared and analysed using the software CSI Bridge. Further, the bridge analysed are checked for class A and class AA loadings.

IV. METHODOLOGY

The research work comprises a study of response of bridge deck for both types of bridges (cable-stayed bridge and extradosed bridge) for various different spans and 70R loading. The parametric study includes response of deck, deck moment, study of pylon, how the response of bridge varies span wise, from aesthetics point of view feasible bridge structure, pylon height and span length to thickness of girder ratio. Check the bridge analysed for class A and class AA loading. The model will be developed using CSI Bridge software.

V. ANALYSIS USING CSI BRIDGE

The paper presents parametric study of cable stayed bridge and extradosed bridge, with fix common parameters. These bridges are analysed for span of 100m, 150m, 200m, 250m and 300m.

Fixed parameters of bridge and data taken for analysis are as follows:

Deck type: Box Girder
Width of bridge: 9.4m (two lanes)
Tendon profile: parabolic
Time variables: creep and shrinkage included.
Vehicle loading: IRC 70R-Wheeled loading (as per IRC)
Staged analysis done in cable stayed and extradosed bridge.
Bridge impact factor: 1.088 (as per IRC)

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Concrete: M75
Steel: Fe1800

VI. MODELLING

Following steps were followed while generating models for different spans:

A. Selecting layout line.
B. Selecting Frame Properties.
C. Selecting Material Properties.
D. Draw pylon.
E. Select required deck section.
F. Define Discretization points.
G. Select Link properties.
H. Draw rigid links.
I. Select Cable properties.
J. Draw cables.
K. Define groups.
L. Assign groups.
M. Assign Supports.
N. Define construction stages.
O. Define lanes.
P. Assign loads.
Q. Run.

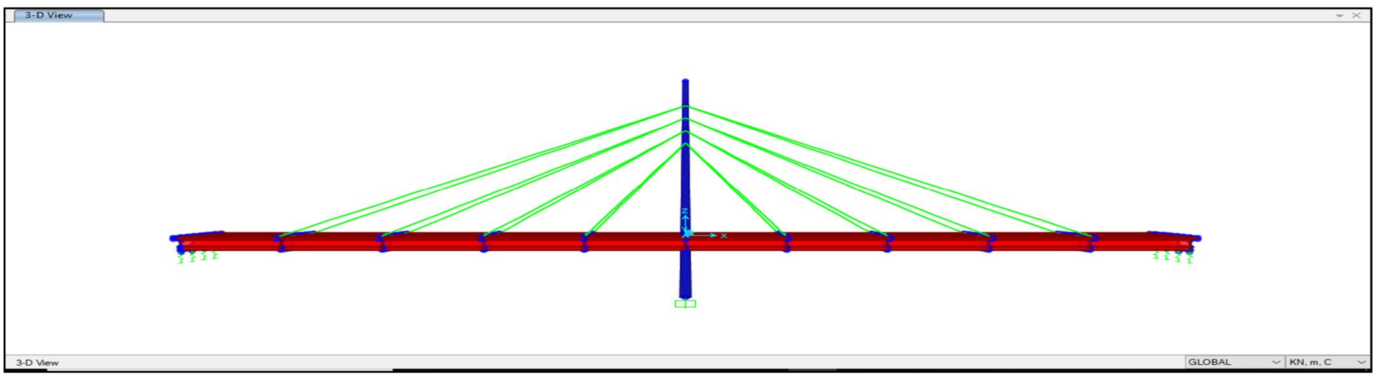

Figure 1: 3D model of Cable-Stayed Bridge for 100m span.

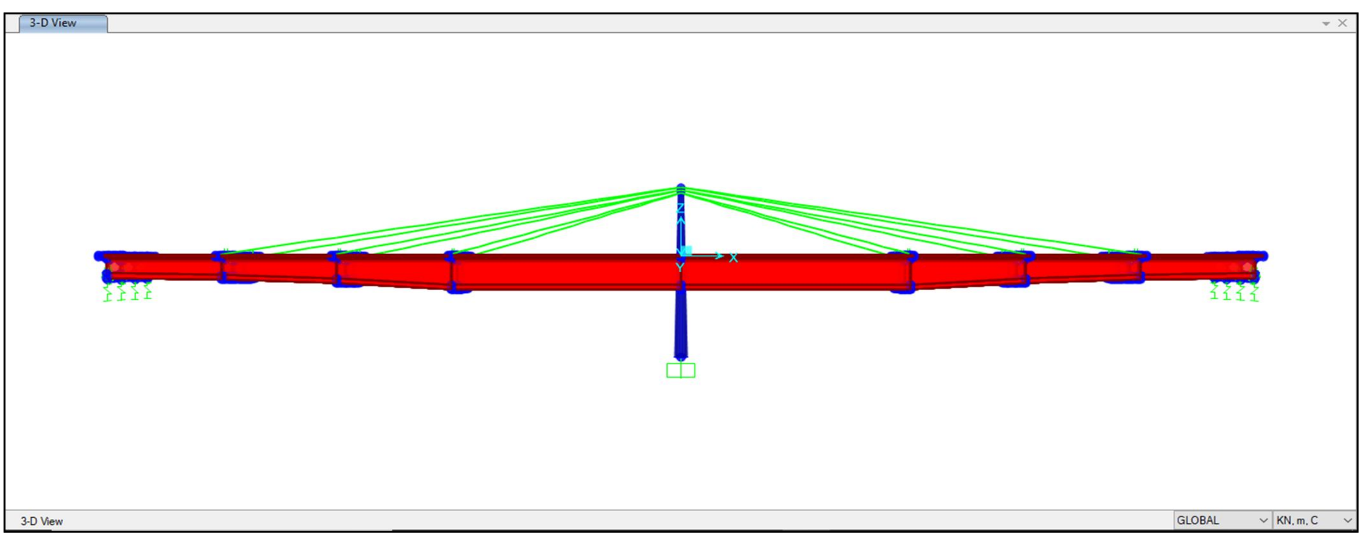

Figure 2: 3D model of Extradosed Bridge for 100m span.

VII. RESULTS

A. Bending Moment

Table i bending moment values for cable-stayed bridge (csb) and extradosed bridge (exb).

Span M	Bending Moment kNm	
	CSB	EXB
100	-69751.9	-57548.4
150	-104773.9	-68437.1
200	-117792.0	-79727.1
250	-144235.2	-93800.2
300	-168451.1	-76214.4

(Note: -ve sign indicates hogging moment)

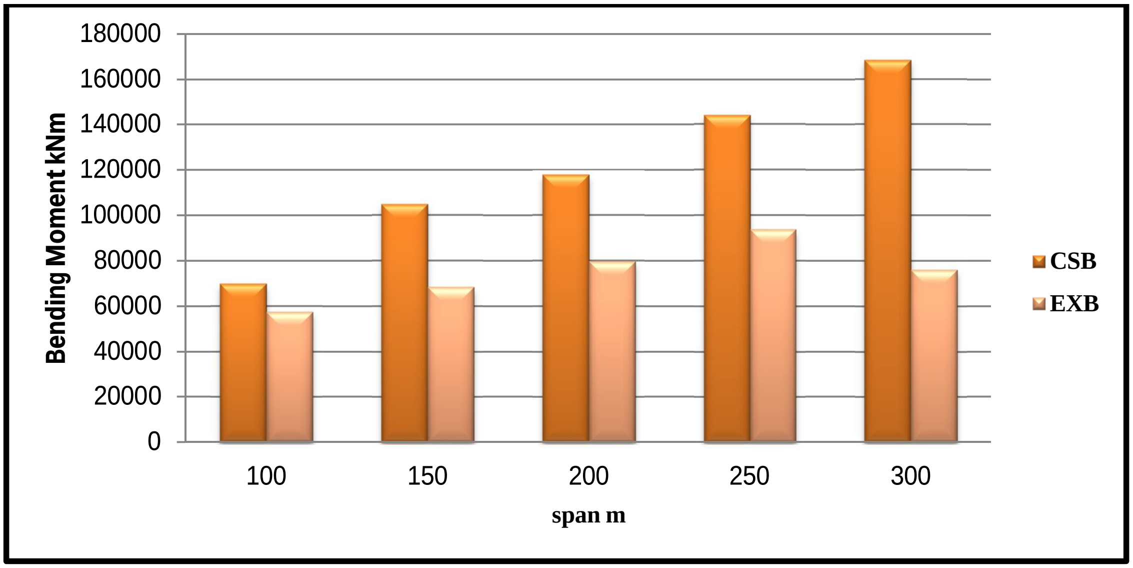

Figure 3: Variation of Bending Moment for cable-stayed bridge (CSB) and extradosed bridge (EXB).

B. Shear Force

Table ii shear force values for cable-stayed bridge (csb) and extradosed bridge (exb).

Span m	Shear Force kN	
	CSB	EXB
100	2054.769	2131.719
150	2093.445	2133.926
200	2089.901	2133.926
250	2103.783	2133.927
300	2111.321	2134.05

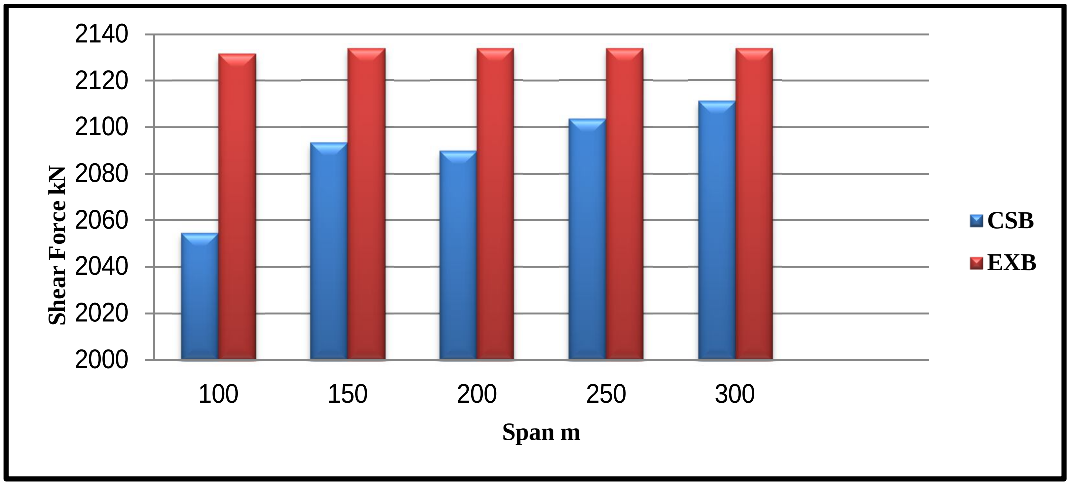

Figure 4: Variation of Shear Force for cable-stayed bridge (CSB) and extradosed bridge (EXB).

C. Pylon Height

Table iii pylon height values for cable-stayed bridge (csb) and extradosed bridge (exb).

Span m	Pylon Height M	
	CSB	EXB
100	25	6.7
150	37.5	12.5
200	50	16.67
250	62.5	25
300	75	30

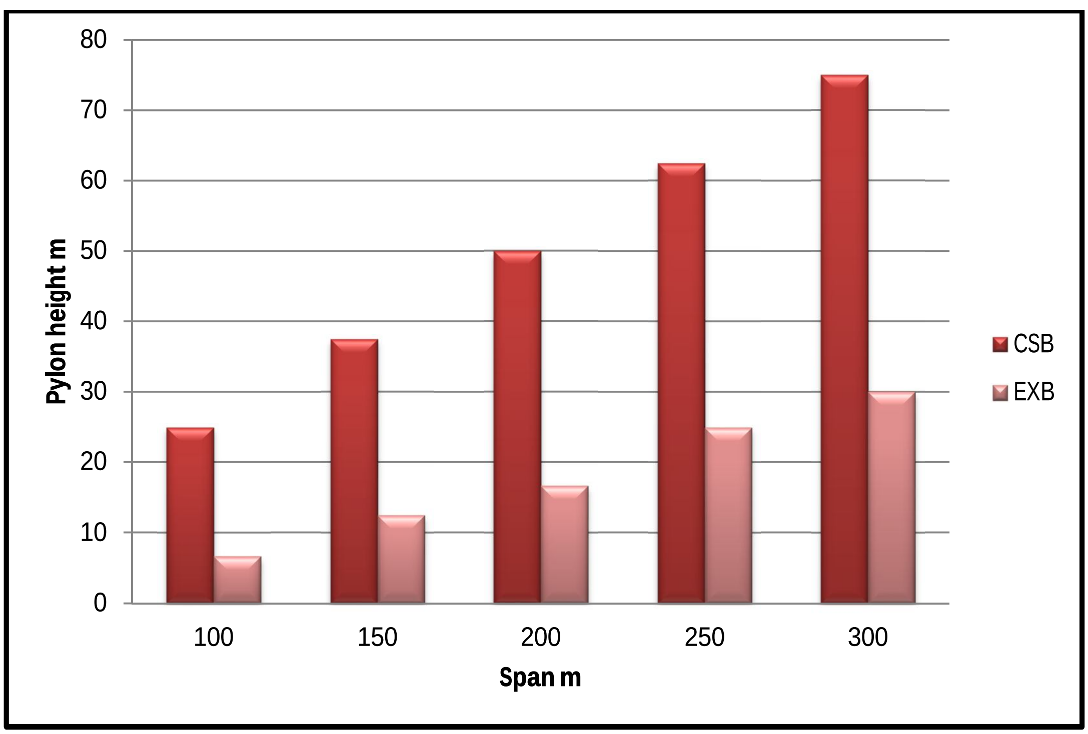

Figure 5: Variation of Pylon Height for cable-stayed bridge (CSB) and extradosed bridge (EXB).

D. Girder Depth

Table iv girder height values for cable-stayed bridge (csb) and extradosed bridge (exb).

Span m	Girder Depth m	
	CSB	EXB
100	2	3.33 (6)
150	3	3 (6)
200	3.5	3.6 (5.7)
250	3.5	4 (6)
300	4	4 (6)

(Note: Depth of girder for extradosed bridge at mid span is given and bracket values indicate depth of girder at pylon.)

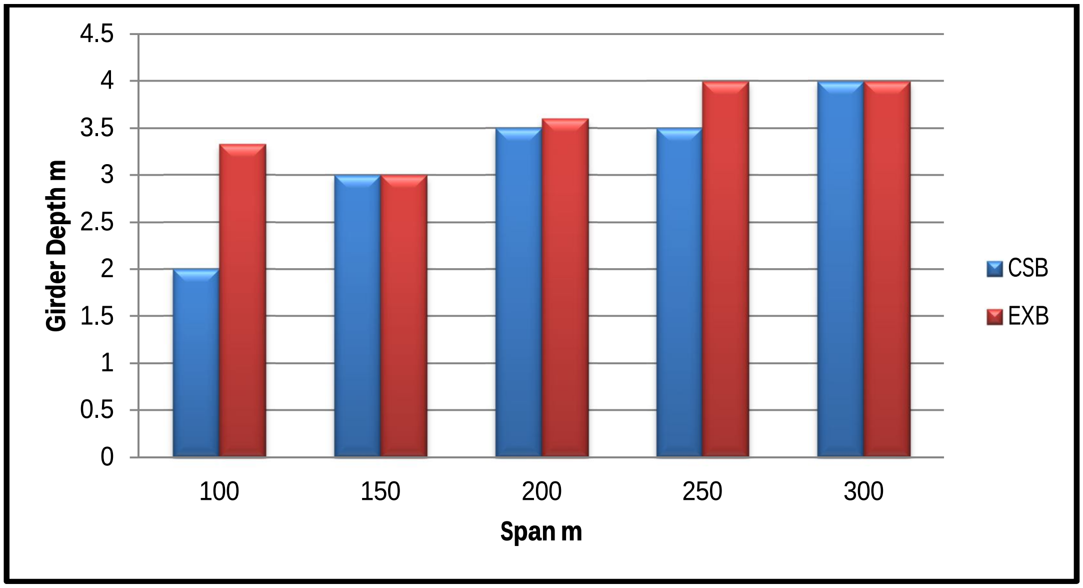

Figure 6: Variation of Girder Height for cable-stayed bridge (CSB) and extradosed bridge (EXB).

VIII. OBSERVATIONS AND DISCUSSIONS

Extradosed bridges are distinguished from Cable-stayed bridges in their structural aspects. After analysing, bridge models for 100m, 150m, 200m, 250m and 300m span are created and the observations are as follows:

It is observed that the pylon height of cable-stayed bridge is double the height provided for extradosed bridge. The lower tower height in proportion to the main span, of extradosed bridge is the distinct feature of this bridge. From the literature study it is observed that various authors have mentioned various ratios for the pylon height (Benjumea) (Biliszczuk).This increases the aesthetic view of the structure. Due to lower tower height this structure can be used where tower heights are limited for e.g. near the airport vicinity.

It is observed that the stay cables placed in extradosed bridges are at flat angles. As tower height is low, the stay cables are placed at shallow angles. Cable-stayed bridges have higher tower height and hence larger stay cable angles. Due to larger tower height they cannot be used in vicinity where the structure height is restricted.

It is observed that the zone near the pier is left unsupported by stay cables in extradosed bridge whereas in Cable-stayed Bridge stay cables are provided. The zone near the pier is left unsupported by stay cables because it is considered that the vertical loads in this zone are directly transferred to the pier rather than carrying the loads upwards to the pylon by stay cables and transferring the same load back to the pier. Authors have recommended that the first tension should be fixed between certain limits from centre span (Benjumea).

It is observed that cable-stayed are provided with constant deck depth whereas extradosed bridges are provided with variable girder depth. Since the zone near the piers in extradosed bridge transfer loads directly to the piers the depth of girder in that zone is increased (by providing deck haunch). Cable-stayed bridges have been provided with stay cables placed near the pylon hence they have constant girder depth throughout the span.

It is observed that more number of cables is required in Cable-stayed Bridge to support the deck whereas in Extradosed Bridge for same spans less number of cables is required. As the stay cables of extradosed bridge do not extend along the full length of the deck.

Cable-stayed bridges have greater bending moment values compared to extradosed bridge for the same length span.

It is observed that Shear force values obtained for both type of bridges are nearly same.

IX. CONCLUSION

Extradosed bridge can be adopted alternative to cable-stayed bridge when overall height is restricted.

The lower tower height not only reduces the material consumed but also reduces construction difficulty. The technique of cable anchoring in extradosed is simpler than anchoring technique used in cable-stayed bridge.

As the stay cables of extradosed bridge do not extend along the full length of the deck they reduce the portion of superstructure live load that is carried by the cables.

From aesthetic consideration, Extradosed bridges give creative yet more economically affordable designs compared to cable-stayed bridge.

Extradosed bridge option is more competitive under similar span lengths owing to the lower construction cost, better constructability and easier maintenance.

REFERENCE

[1] Benjumea, J., Chio, G., Maldonado, E. (2010). "Structural behaviour and design criteria of extradosed bridges: general insight and state of the art". Revista Ingenieria de Construction (journal of construction engineering) Vol. 25.
[2] Biliszczuk, J., Onysyk, J., Barcik, W., Toczkiewicz, R., Tukendorf, A. (2017). "Extradosed Bridges in Poland-Design and Construction". Technology Report 03 doi: 10.3389/fbuil.2013.00037.
[3] Bujnak, J., Odrobinak, J., Vican, J. (2013). "Extradosed Bridge – Theoretical and Experimental Verification". Concrete and Concrete Structures 2013 Conference. Elsevier, Procedia Engineering 65 (2013) 327-334.
[4] Ikeda, S., and Kasuga, A. (2000). "Development of extradosed structures in the bridge construction". 25th Conference on our world in concrete & structures, Singapore.
[5] Mathivat, J. (1988). "Recent developments in prestressed concrete bridges". FIP Notes, 2, 15-2.
[6] N. Krishna Raju, "Design of Bridges", Third Edition, (2009).
[7] IRC: 18-2000. Indian Road Congress 2000. Design Criteria for Prestressed Concrete Road Bridges.
[8] IRC: 6-2014.Indian Road Congress 2014. Standard Specifications and Code of Practice For Road Bridges. Section: II – Loads and Stresses.
[9] IRC 21-2000. "Standard Specification and Code of Practice for Bridges ", Section: III, "Cement Concrete (Plain and Reinforced Concrete) ", Third Revision.
[10] IS 456-2000. "Indian Standard Plain and Reinforced Concrete – Code of Practice", Fourth Revision.