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Short Communication

The Main Structure of the Prestress Bridge: Ultimate Calculation Analysis Using Bridge Management System (BMS 1992) Planning Method

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ABSTRACT

One of the functions of the bridge is as a medium between two parts of the road that are cut off, the existence of a bridge construction facility is very beneficial for the local community from an economic and social perspective. This analysis aims to determine the dimensions of the structure that will be used in determining the forces acting on the main structure of the bridge, especially the ultimate force in controlling the beams in the main structure. The main beam uses AASHTO standard prestressed beam type V, with a beam height of 1600 mm, with an initial prestressing force of F = 691943,478 Kg and after calculating the initial prestressing loss of 20%. By controlling the stress that occurs at the time of transfer (jacking) on the top fiber of 24,457 Mpa and on the bottom fiber of -130.618, the stress when the load is off when the top fiber is -13,033 Mpa and at the bottom fiber is -7,653 Mpa, the stress when the load is on at the top fiber of -13.033 Mpa and at the bottom fiber of -7.653 Mpa.

Keywords: Beam dimensions, prestressing force, ultimate load

INTRODUCTION

Background

Bridge construction is one of the means for the people of Indonesia as a liaison from one area to another, especially for areas that are still far behind in the field of bridge construction, which is one of the construction transportations tools that serves to connect two broken roads. "Bridges shall be designed for specified limit states to achieve the objectives of constructibility, safety, and serviceability, with due regard to issues of inspect ability, economy, and aesthetics, as specified in Article 2.5."[1] "In the mid-19th century, with the development industry sector, vehicles and trains entering into circulation using the current transportation system. Therefore, a greater number of roads, railroad and bridges were built to serve the increase of transportation demands."[2] Mandić et al. argue "A great number of existing Croatian bridges have been designed according to old codes, so changes in requirements of new standards and time-variability of loading result with the fact that bridges have different reliability levels."[3]The purpose of the bridge is that pedestrians and other modes of transportation can pass easily, and can have an impact on the local community from both an economic and social perspective. The bridge that crosses the river is a means of land transportation. which is wide enough to make the bridge to be built is included in a long span bridge, where the span of the bridge to be made has a span length of ± 60 m. From the above conditions, it is necessary to plan a main structure on the bridge using the Bridge Management System 1992 (BMS 1992) guidelines. The main structure of the prestress bridge with the management system method (BMS 1992) is calculated in the ultimate.

Purpose

The purposes are to determine the dimensions of the structure to be used and the forces acting on the main structure of the bridge, especially the ultimate force to control the dimensions of the beams in the main structure. With reference to the main structure, there are nine aspects that need to consider, such as, structural strength, economy, local conditions, beam planning, calculation of loss of prestressing force, ultimate style influence, beam cross, beam loading, and determining the prestressing force.

MATERIALS AND METHODS

General Design Requirements

On the basis of the bridge management system (BMS 1992), its basic principles of planning cover ultimate limit state, and serviceability limit state.

Ultimate Limit State

Slawomir and Mateusz argued "According to all of the twentieth century bridge standards concerning road structures, including Eurocodes, the statics is the only method of bridge design."[4] Tabarroki et al. stated "there are two main aspects in the definition of characteristic values: (a) a 36 cautious estimate, and (b) the value affecting the occurrence of the limit state."[5] Hellesland et al. stated"… the design of a reinforced concrete section at the ultimate limit state (ULS) is considered by using a rectangular simplified law for the compression concrete block, and a bilinear law for the steel that accounts for the hardening behavior. This design is compatible with Eurocode 2 material parameters."[6] Casandjian et al. stated that "A limit law, for a given material, is defined from the overall possible configurations reached by this material and is compatible with a given state criterion. A limit law, in its essence, is different from a constitutive law; the constitutive law implicitly contains all the successive temporal configurations before reaching the limit state. Therefore, in the concept of limit law, the notion of the stress or strain path is replaced by the notion of the limit state, which is the set of configurations compatible with a given state criterion."[7] Casandjian et al. added that "In the case of the limit behavior of concrete at the SLS (serviceability limit service), a section at its limit state will have a linear distribution of stress in the compressed part of the section (as a consequence of Bernoulli kinematics and elasticity behavior of each material at the SLS), the contribution of concrete in tension being neglected as a fundamental assumption." Lam et al. stated that "The bridge loads are unsafe and the reaction that the bridge exerts against them is called the ultimate limit state. The central concepts of limit state design are as follows: (1) All the separate conditions that make the structure unfit for use are taken into account. These are the separate limit states. (2) The design is based on the actual behaviour of materials and performance of structures and members in service. (3) Ideally, design should be based on statistical methods with a small probability of the structure reaching a limit state."[8] Lam et al. added that "The ultimate limit states include the following: (1) strength (including general yielding, rupture, buckling and transformation into a mechanism); (2) stability against overturning and sway; (3) fracture due to fatigue; (4) brittle fracture. When the ultimate limit states are exceeded, the whole structure or part of it collapses (p. 9).

Serviceability Limit State

Mojtabaei et al. argue that "There is a general consensus that a structure must be designed to resist both service and extreme load conditions with the acceptable level of reliability during its effective life. However, the aforementioned literatures mainly focused on Ultimate Limit State (ULS), which conventionally represents the ultimate strength of the CFS structures under extreme load events. It should be noted that the level of slenderness for CFS elements is normally higher than hot-rolled steel counterparts, and therefore, the Serviceability Limit State (SLS) is generally more critical for CFS structures."[9] Mojtabaei et al. added that "Violation of serviceability requirements (e.g. deflection limits) implies that the structure would be unfit for normal service operations."

The serviceability limit state is the less severe condition associated with deflection, cracking and vibration, which would be achieved if the reaction of the bridge was sufficient to render the bridge unfit for use, or cause a general concern for bridge safety, or substantially reduce the strength and service life of the bridge.

Bridge Geometric Requirements

While considering ASME Y14.5M-1994 (1994) on geometrical dimensioning and tolerancing concepts, Saravanan et al. noted "… four complications: 1. lack of relation between the two design stages, 2. geometrical dimensioning and tolerancing (GD&T) methodology not available at the initial assembly design stage, 3. conflict between design and manufacturing departments and 4. minimum relative manufacturing cost with maximum interchange ability. In planning the bridge, the shape and requirements must be determined so that the bridge built can provide optimal service to bridge users."[10]

Road Plan Class

When discussing a functional road classification with data mining techniques, D'Andrea et.al. "The selection of the class (from A to F, according to the Italian standard) derives from a complex process which comprises surveys of the road context and the following analysis of the collected data: this process, however, can also terminate with a judgment of un-classification, with the consequent necessity of adjustments in the road itself and the need to determine safety measures to be applied during the transition period."[11]In case of road functional classification using pattern recognition techniques, Bosurgi et al. argue that "… the vehicular flow mobility has numerous analogies with the blood circulation: the more the transport system is similar to the blood vessel system in the human body, the higher its efficiency level. In the human body, a network of thick vessels start from the heart and, moving away from it, they become thinner and thinner, to thoroughly and efficiently perfuse all the human organs."[12]

Road Width

Nasution et al. argued "… discuss on a system for road information collecting and road width measurement. The system aims to give proper alternate routes based on the vehicle's type. The process uses a crowd sourcing approach by using the application in a driver's smartphone which will capture road situation and traffic condition during the trip."[13]"… we use high and mid resolution satellite data, combined with intense field measurements along urban-rural transects to evaluate some key urban parameters, including urban fractions and road width, and to get better spatial estimates of those parameters for the region."[14] The provisions in the BMS 1992 in article 5.1.2. concerning number of traffic lanes and in article 2.3.2. regarding the width and number of planned traffic lanes is shown in Table 1.[15] The type of bridge to be planned is two-way without a median, the width of B = 8 m is taken with 2 lanes of traffic.

Table 1: Number and width of planned traffic lanes

Bridge Type	Bridge Roadway Width (m)	No. of Design Traffic Lanes
Single Lane	4.0 – 5.0	1
Two-Way, No Median	5.5 – 8.25	3
	11.25 – 15.00	4
Multiple-Roadway	10.0 – 12.9	3
	11.25 – 15.0	4
	15.1 – 18.75	5
	18.8 – 22.5	6

Source: BMS 1992, Article 2.3.2.c.[15]

Loading/Burden on the Bridge Structure

With reference to bridge reinforcement, Sumendap et al. argued "Because the load of the middle girder is greater than edge girder then the dimension of the edge girder is made uniform with center girder. The following is the capacity of each dimension of the girder is limited with Asc/bd minimum = 0.0035 and Ast/bd maximum = 0.0634 to the bridge span that calculated based on the 1992 BMS loading and SNI 2005 and using concrete quality (fc') 30 MPa and steel quality (fsy) 240 MPa."[16]The loading refers to the load that arises on a bridge based on the existing regulations in the BMS, 1992.The expenses that arise are divided according to their source into several groups, namely:[15]

1. Fixed load.
2. Traffic load.
3. Environmental load.
4. Other expenses

Based on the length of the workload, it is divided into two, namely:

1. Fixed loads, which work around the clock and for long periods of time
2. Transient loads, which work in the short term

The classification of actions as above means that the working loads can be estimated at the age of occurrence, and if there is a load that is not common in the regulations, it must be re-examined by taking into account the magnitude of the load factor and the duration of the action. The nominal action calculation is converted into a bridge design action. The combined design load is divided as:

1. Combination in serviceability limit
2. Combination in ultimate power limit
3. Combination based on design based on working stress

Based on the burdens that arise in the planning must be in accordance with existing regulations, the following is an explanation of the planned load and the working load factor.

Live and Dead Loads

"Computing the response of a bridge to live loads is a complex task. The moment demand for a particular girder depends on the magnitude and location of the imposed loads and on the properties of the bridge. The design moment in the girder will vary with girder spacing, span, flexural stiffness, torsional stiffness, and on the properties of the deck and diaphragms."[17]"Loading is defined as the maximum load that can be expected to occur on any bridge length with a particular probability or return period. The maximum load for a short span bridge is caused by the heaviest trucks that can travel over it. For two lane bridges, the extreme load is usually the result of two side-by-side trucks."[18]"The major load components of highway bridges are dead load, live load (static and dynamic), environmental loads (temperature, wind, earthquake) and other loads (collision, emergency braking). Load components are random variables."[19]"The permanent state of stress in a cable-stayed bridge subject to its dead load is determined by the tension forces in the cable stays. They are introduced to reduce the bending moments in the main girder and to support the reactions in the bridge structure. The cable tension should be chosen in a way that bending moments in the girders and the pylons are eliminated or at least reduced as much as possible. Hence, the deck and pylon would be mainly under compression under the dead load."[20]"In continuous steel bridges, the system provides continuity for non-composite dead loads in addition to the superimposed dead load and live loads. In the Simple for Dead Load and Continuous for Live Load (SDCL) system, the girders are spliced at each the pier. The girders span directly from pier to pier (or abutment to pier) within each span. The individual spans are simply supported when the deck is cast."[21]The dead load of the bridge consists of structural weight and non-structural loads, each of which is considered an inseparable load. Based on BMS 1992 article 2.2, each calculated building mass must follow the picture shown and the average mass density of the materials used."[15]

Self-Weight

"The dead load (which acts in the direction of gravity) is high in contrast to the measurement force. The ratio of measurement force to dead load is up to FM/FG = 10-^{7}."[22]The dead load acting on the prestressed concrete bridge is its own weight and additional dead load, as shown in the following table:

Table 2: Nominal and U.L.S material weight

Bridge Materials	Nominal(S.L.S) Self-weightkN/m^3	U.L.S Normal Self-weightkN/m^3	U.L.S Relieving Self-weightkN/m^3
Mass Concrete (C.I.P.)	24	31.2	18
Reinforced Concrete (C.I.P.)	25	32.5	18.80
R.C. or P.S. Concrete (Precast)	25	30	21.30
Steel	77	84.7	69.3
Timber, Softwood	7.8	10.9	5.50
Timber, Hard wood	11.0	15.4	7.7

Source: BMS 1992, Article 2.3.1.a.[15]

Superimposed Dead Load

"For superstructures, simple for dead and continuous for live (SDCL) connections were used to connect the girders and cap beam with cast-in-place concrete and a top layer of UHPC, grouted blockout connections between the girders and prefabricated deck panels, and UHPC connections between prefabricated deck panels."[23] In BMS 1992 section 2.3.1.b, the superimposed dead load refers to the weight of all non-structural elements that differ over the life of the bridge as written in the followings:[15]

- Special surface finish;
- Resurfacing allowance assumed to be 50 mm of asphalt concrete (only applied in adverse cases and assumed to be nominally 22 kN/m3);
- Hand rails, guard rails or concrete barriers;
- Signs;
- Utilities such as water and sewerage pipes (considered empty or full).

In the design of the bridge the asphalt load is not taken into account, this is because the coating on the bridge vehicle floor plate using asphalt will only increase the dead load of the bridge and reduce the serviceability of the bridge. Therefore, sand sheet is used which is a hot mix asphalt which is melted on the surface of the bridge floor with a thickness of 2 cm as a retaining layer for wheel friction.

Effect of Shrinkage and Expansion

"In general, high curing temperature increases the rate of development of autogenous shrinkage but reduces laterage autogenous shrinkage, and vice versa for low curing temperature. The rate of development of autogenous shrinkage is a fundamental factor for the cracking risk, since a slower development of self-induced stresses allows the relaxation process to reduce the stresses in the concrete."[24]The effects of shrinkage and expansion result in moments, shears and reactions into resisted components, in the U.L.S, due to the forces which are generally minimized in the fracture of yielded concrete and steel. According to BDC 1992 article 2.2.4, the effect of expansion and shrinkage calculated using the dead load of the bridge can be reduced due to other loads, minimal expansion and shrinkage values when moving from prestressed concrete.[15]

Effect of Prestressing

"During the early stages of curing, the concrete and prestressing strand temperature increases, which leads to the following mechanism of stress loss."[25]Apart from primary effects, prestressing causes secondary effects in restrained and structurally indeterminate components. According to BMS 1992 section 2.2.5, the prestressed portion due to expansion and shrinkage will cause the main load, as a condition that the prestress will be fully bonded, by calculating the effect of the intact concrete section of 1.0 as a serviceability load factor at the service limit state.[15]

Traffic Load

"The load and material factors are chosen in such way that a safety level (expressed by β) belonging to the vigouring consequence class is obtained. If human safety is the governing factor in the design, one generally wants to have a constant annual failure probability."[26] Traffic with vehicle loads that pass through the lane, where the weight of vehicles that will pass through the bridge is very important for the loading plan of the bridge itself.

Planned traffic lane

"A signalized turn lane may be installed for any of the following reasons: new traffic signals are being installed, there is a history of crashes between turning vehicles and oncoming through traffic, there are two or more lanes that turn across traffic, turning traffic is opposed by two or more through lanes of traffic, two or more opposing through traffic lanes have high operating speeds, and sight distance to the intersection is limited."[27]The traffic load for the design consists of the load due to lanes, the load due to trucks placed across the road, bridge vehicles which have an effect on the equivalent value in the actual series which depends on the width of the bridge vehicle road. The weight of a single load vehicle on a truck with three axles at any position in the design traffic lane, each axle consisting of two loading contact areas to represent the effect of the wheels of the heavy vehicle.

Lane Loads

The lane load consists of:

1. The evenly distributed load (UDL) depending on the intensity q kPa, on the total loaded length (L) as follows:

$L \leq 30\ m\ ;\ q = 8{,}0\ kPa \ldots\ldots (1)$

$L\ > 30\ m\ ;\ q = 8{,}0\ \left(0{,}5 + \frac{15}{L}\right) kPa.\ldots\ldots\ldots (2)$

UDL loads can be placed at intermittent lengths for maximum impact. L is the sum of the lengths of each disconnected load, which is placed perpendicular to the direction of traffic, as shown in the following figure:

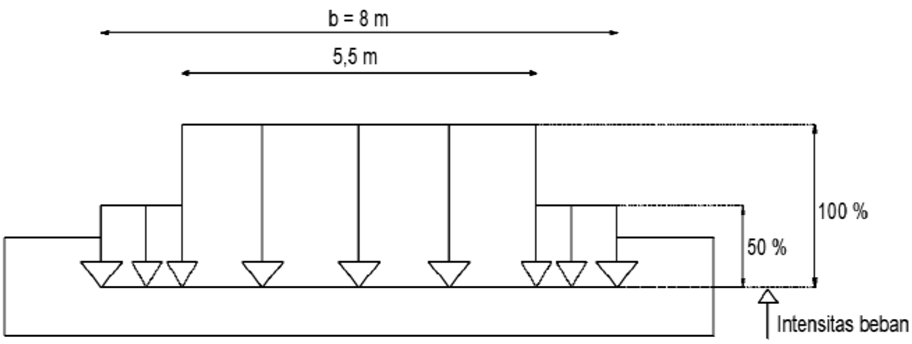

Figure 1.Lane load position
Source: BMS 1992[15]

2. Line load (KEL) of p KN/m, placed in any position along the bridge and perpendicular to the direction of traffic: P = 44,0 KN/m

Truck Load

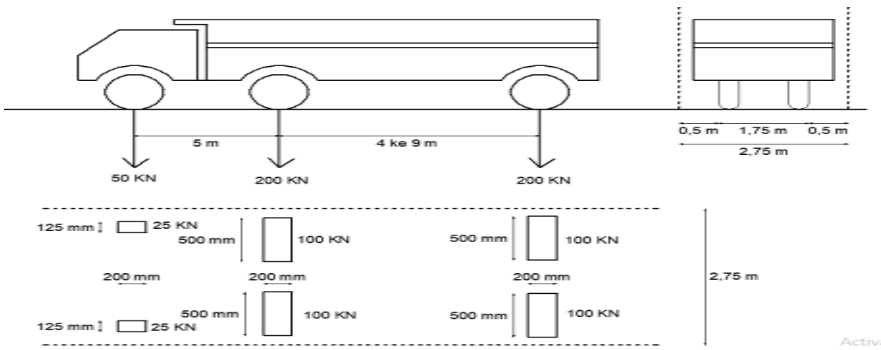

Figure 2: Truck load position
Source: BMS 1992[15]

Truck loads are placed in the middle of the traffic lane, as shown in Figure 2, where the truck load positions are located in each planned traffic lane for the full length of the bridge.

Environmental Burden

Environmental loads in the form of the influence of wind, temperature, floods, earthquakes and other natural causes. The amount of burden given is based on statistical analysis of general events. Environmental loads is based on BMS 1992.

Wind Load

The design wind speed and the shape of the bridge are the main factors that affect the intensity of the wind load that occurs. The design wind speed is based on BMS 1992 article 2.4.6, the ultimate nominal force and the serviceability of the bridge due to wind depend on the design wind speed as follows:

$T_{EW} = 0{,}0006 \, . \, C_w \, . \, (V_w)^2 \, . \, Ab$ KN ……….(3)

Where:
V_w= design wind speed (m/s) for the boundary conditions under review (table 2.2)
C_w= drag coefficient (table 2.3)
Ab = Coefficient area of the side of the bridge (m2)

The wind is considered to work evenly on all superstructures, if a vehicle is on the bridge, then the additional uniform load in the horizontal direction must be applied to the floor surface with the formula:

$T_{EW} = 0{,}012 \, . \, C_w \, . \, (V_w)^2 \, . \, Ab$ KN/m …….(4)

Table 3: Planned wind speed

Border Condition	Location	
	<5 km from beach	**> 5 km from beach**
Serviceability	30 m/s	25 m/s
Ultimate	35 m/s	30 m/s

Source: BMS 1992[15]

Earthquake Load

The effect of earthquake loads is used at the ultimate limit state, by means of an equivalent static load for the minimum seismic design concrete in accordance with BMS article 2.4.7, namely:[15]

$T'_{EQ} = K_h \, . \, I \, . \, W_t$ ………….. (5)

Where:
$K_h = C \, . \, S$
T'_{EQ}= total base shear force in the direction under consideration (KN)
K_h = horizontal seismic load coefficient
C = basic shear coefficient for the appropriate time zone and local conditions
I = Interest factor
S = building type factor

Table 4: Drag coefficient (Cw)

Type	Cw
Massive superstructure	
b/d = 1,0	2,1
b/d = 2,0	1,5
b/d ≥ 6,0	1,25
Building on frame	1,2

Source: BMS 1992[15]

W_t= total nominal weight of the building that affects earthquake acceleration, taken as additional dead load.

DISCUSSION

Master Beam Planning

In planning the dimensions of the main beam on the bridge by analyzing the dimensions of the main beam and its characteristics. Where the length of the plan is 30 meters to determine the height of the beam (h) So the dimensions for this main girder are:

$$\frac{30}{20} - 0{,}20 \le h \le \frac{30}{20} + 0{,}50$$
$$1{,}30\, m \le h \le 2{,}00$$

Then use h = 1,600 m = 160.0 cm
Mid-Span Main Beam Design

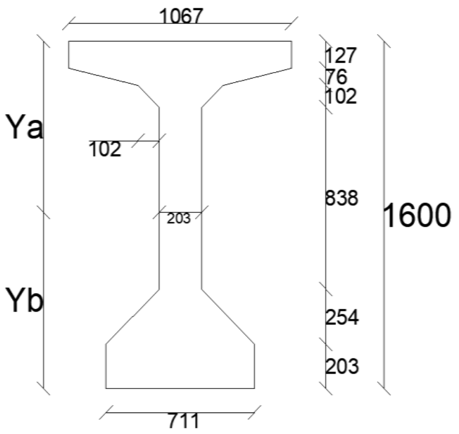

Table 5: Properties of blocks AASHTO – PCI Type IV

Block type	Width, X 10^4 mm^2	I, X 10^8 mm^4	Cb, mm	Proposed span Boundary (m)
V	65,35	2169	812	27,4 -36,6

Source: Lin and Burns, 1981[28]

Then: Ac = 653500 mm^2

I = 2169 x 10^8 mm^4

Cb/Yb = 812 mm

Ya = h -Ya =1600-812= 788 mm

$$r^2 = \frac{I}{Ac} = \frac{2169\ x\ 10^8}{653500} = 331905{,}126\ mm^2$$

Beam yield control:

$$\rho = \frac{r^2}{ya\ x\ yb} = \frac{331905{,}126}{812\ x\ 788} = 0{,}519$$

ρ ≤ 0,45 beam dimensions are too fat

ρ = 0,50 balanced beam dimensions

ρ ≥ 0,55 beam dimensions are too slender and difficult to implement

Then the dimensions of the beam include a balanced beam

$$wa = \frac{I}{Ya} = \frac{2169\ X\ 10^8}{788} = 275.253.807{,}107\ mm^3$$

$$wb = \frac{I}{Yb} = \frac{2169\ X\ 10^8}{812} = 267.118.226{,}601\ mm^3$$

$$ka = \frac{wb}{Ac} = \frac{267118226{,}601}{653500} = 409\ mm$$

$$kb = \frac{wa}{Ac} = \frac{275253807{,}107}{653500} = 421\ mm$$

Main Beam Cross Section Design at Support

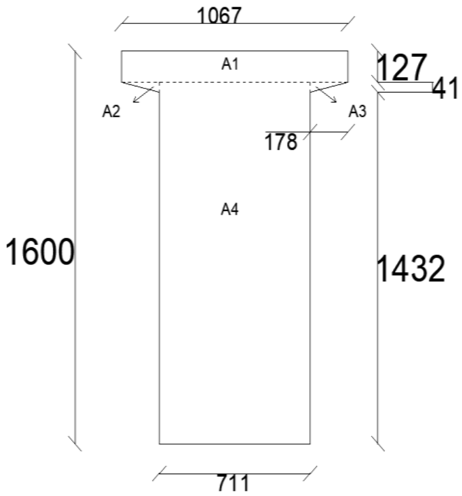

Figure3: AASHTO-PCI type V beam cross-section on pedestal
Source: Lin and Burns, 1981[28]

Block cross-sectional area (Ac):

$$A1 = b\ x\ h = 1067\ x\ 127\ = 135509\quad mm^2$$

$$A2 = \frac{b\ x\ h}{2} = \frac{178\ x\ 41}{2} = 3649\quad mm^2$$

$$A3 = \frac{178\ x\ 41}{2} = 3649\quad mm^2$$

$$A4 = 711\ x\ 1432\qquad \underline{= 1018152\ mm^2 +}$$

$$Ac = 1160959\ mm^2$$

Center of gravity of the block (c.g.c.):

$$Yb = \frac{\sum(A_n\ x\ y_n)}{\sum A}$$

$$= \frac{\left(135509\ x\left(1600 - \frac{127}{2}\right)\right) + \left(2\ x\left(3649\ x\left(1432 - \frac{41}{3}\right)\right)\right) + \left(1018152\ x\frac{1432}{2}\right)}{135509 + 3649 + 3649 + 1018152}$$

$$= \frac{(135509\ x\ 1536{,}5) + (2\ x(3649\ x\ 1418{,}333)) + (1018152\ x\ 716)}{1160959}$$

$$Yb = 816\ mm$$

$$Ya = 1600 - 816 = 784\ mm$$

The moment of inertia of the beam cross section:

$$I = \sum(i_n + yi_n)$$

$$I = \left(\frac{1}{12}\ x\ 1067\ x\ 127^3 + 135509\ x\ 720^2\right) + (2\ x\ (\frac{1}{36}\ x\ 178\ x\ 41^3 + 3649\ x\ 602^2)) + \left(\frac{1}{12}\ x\ 711\ x\ 1432^3 + 1018152\ x\ -100^2\right)$$

$$I = 257344761169{,}777\ mm^4$$

$$r^2 = \frac{257344761169{,}777}{1160959} = 221665{,}676\ mm^2$$

$$wa = \frac{257344761169{,}777}{784} = 328323374\ mm^3$$

$$wb = \frac{257344761169{,}777}{816} = 315301969{,}4\ mm^3$$

$$ka = \frac{315301969,4}{1160959} = 272\ mm$$
$$kb = \frac{328323374}{1160959} = 283\ mm$$

Composite Section Calculation

In the calculation of this composite cross section, the width of the reinforced concrete slab replacement (bef) is calculated as follows:
Prestressed concrete quality:
fc' = 50 Mpa
(mass density),
We = 2560 Kg/m^3

Modulus of elasticity of concrete at a certain age Eci. The ECI used with the 1992 BMS BDC method article 6,4,1,2 is as follows:

$$Eci = (we)^{1,5} .\ (0,0043 .\ \sqrt{fc'})$$
$$Eci = (2560)^{1,5} .\ (0,0043 .\sqrt{50}) = 39383,418\ Mpa$$

Reinforced concrete quality:
fc' = 30 Mpa
(mass density),
We = 2400 Kg/m^3
Modulus of elasticity of concrete at a certain age Eci. The ECI used with the SKSNI method article 3,1,5 is as follows:

$$Eci = 4700 .\sqrt{fc'}$$
$$= 4700 .\sqrt{30} = 25742,960\ Mpa$$

$$n = \frac{Ec_{balok}}{Ec_{Plat}} = \frac{39383,418}{25742,960} = 1,530$$

Jarak antaragelagar (s):Distance between girder(s):

$$s = 2\ m$$
$$bef = \frac{s}{n} = \frac{2}{1,530} = 1,307\ m = 130,7\ cm$$

Plate cross-sectional area
$$= 130,7\ x\ 25 = 3268\ cm^2$$

Composite Section at Mid-Span

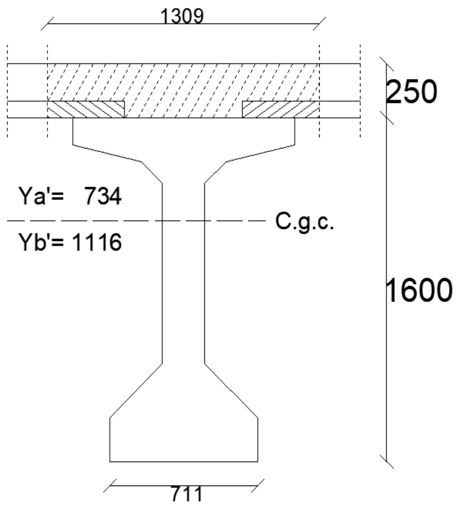

Figure 4: Place of c.g.c. mid span composite

Cross-sectional area include:
A' cross-section
$$= A\ girder + A\ plate$$
$$= 6535\ cm^2 + 3268\ cm^2 = 9803\ cm^2$$
Location of center of gravity of the mid-span composite section:
$$Yb' = \frac{3268\ x\ 173 + 6535\ x\ 81,2}{9803} = 111,6\ cm$$
$$Ya = 185 - 111,6 = 73,4\ cm$$

CONCLUSIONS AND SUGGESTIONS

Conclusions

We conclude in the followings:

1. Planning a bridge span of 60 meters, which is divided into 2 equal lengths with each span of 30 meters long, where each span has the same width, which is 11 meters.
2. The main beam uses AASHTO standard prestressed beam of type V, with a beam height of 1600 mm, with an initial prestressing force of F = 691943,478 kg and after calculating the initial prestressing loss of 20%.
3. By controlling the stress that occurs at the time of transfer (jacking) on the top fiber of 24,457 Mpa and on the bottom fiber of -130.618, the stress when the load is off at the top fiber is -13.033 Mpa and at the bottom fiber is -7.653 Mpa, the current stress live load at the top fiber is -13.033 Mpa, and at the bottom fiber is -7.653 Mpa.

Suggestions

From the conclusions, two suggestions are provided as follows:

a. The quality of road performance in a traffic order area requires an active role from the government as a regulator and public awareness as users.
b. Due to the existence of Transport Demand Management (TDM), it is necessary to improve transportation by widening roads or other things of a physical nature;

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