DESIGN OF FLYOVER TRANSVERSE VERTICALLY BY USING HYDRAULIC JACK

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Abstract - *This paper deals with the purpose of Passover in congested area. Now a day's flyover plays a vital role in reducing and diverting the intensity of traffic on major cities. By using Hydraulic jack the over pass can be transverse vertically. The over pass is made up of composite materials i.e. concrete and steel structures. With the help of pile foundation, loads are transferred deep into the soil. The structural members of deck and pier are made up of Aluminium and steel structures. The proposal of this project is to implement the over pass where land acquisition cost is high and also in congested areas. In this project, analysis and design of flyover is done.*

Keywords: Steel beams; Hydraulic jack; composite materials; nonlinear analysis; Passover; Finite element method.

1. INTRODUCTION

The difference between Bridge and Flyover is based on the purpose of its usage and the location where it is built. Bridges are built to connect two points separated by a naturally occurring region like valley, river, sea or any other water bodies, etc. Flyover is built to connect two points in congested areas or roads and intersection of roads. Bridge and flyovers are structures providing passage over an obstacle without closing the way beneath. The required passage may be for a road, railway or a valley. Flyover design is a complex problem, calling a creativity and practicability, while satisfying the basic requirement of safety and economy. The basic design philosophy governing the design is that a structure should be designed to sustain, with a defined probability, all action likely to occur within its intended life span. In addition, the structure should maintain stability during unprecedented action and should have the adequate durability during its life span.

India has a rich history of steel bridges and flyovers. These are generally road flyover over low terrains or roads or intersection joining long distance through single span or multiple span constructions. Steel bridge and flyover are ideal solution for long spans, construction in hilly areas or terrain conditions. For the short and medium span bridges and flyovers Steel – concrete composite construction is gaining popularity. Some of steel bridges in India are about 100 years old and yet going steady, demonstrating the long life performance of steel bridges. In India due to high population density, most of the cities are saturated and traffic congestion is one of the major problems faced by these cities. Construction of flyovers is a solution to this problem. But construction of flyovers using R.C.C is time consuming, and will affect existing traffic and it has low seismic resistance. Construction of flyovers using steel sections can overcome these disadvantages, even though its initial cost is high. A flyover and bridge has three main elements. First, the substructure (foundation) transfers the loaded weight of the bridge and flyover to the ground; it consists of components such as columns (also called piers) and abutments. An abutment is the connection between the end of the bridge and road carried by earth; it provides support for the end sections of the bridge and flyover.

1.1 Objective

The project area is congested due to the presence of National highways inside the city, therefore the flyover is essentially required at this junction. Our project deals with the Design of steel flyover in the city. We have designed the longitudinal girder and composite deck slab are designed for this grade separator.

1.2 Site Study and Analysis

The project deals with the construction of flyover and bridge at Kanchipuram junction, which connects 4 state highways. This site is highly commercial and has a dense traffic throughout the week and hence an alternative route for the traffic is also suggested but unable to implement.

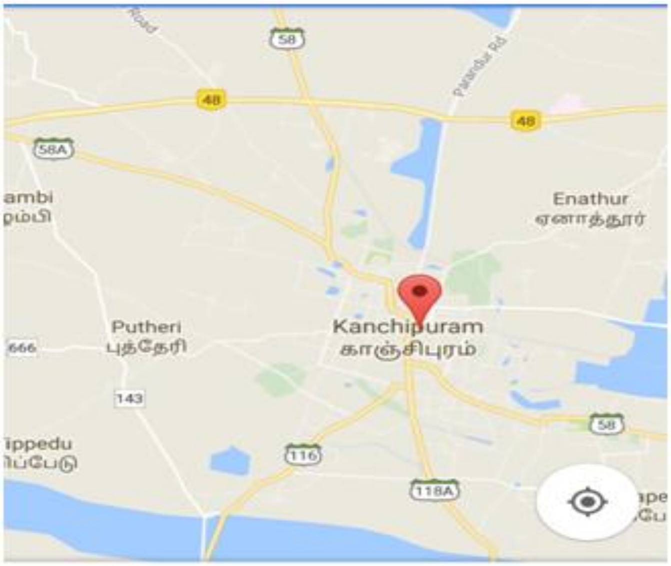

Fig -1: Location of the Project

2. STRUCTURAL DETAILS OF THE FLYOVER

A minimum vertical clearance of 7metres above the ground level. The overall length of columns is 9m. The column is divided into 3 nos. Each column has 3m height. Overall length of the flyover is 500metres. The embankment length is 1/3rd portion of length of the flyover. Embankment length is 100m from each end of flyover. The vertical portion is 300m. Width of flyover is 7.6m. Flyovers have been designed as bi-directional (each two lane) with design speed of 50 kmph. It is located at the inner part of the city. The width of single lane is 3.5m. Kerb is provided at both ends 200mm wide. The width of the median is 200mm. The length of span is 10m. Super structure is consisting of PCC over the length. PCC placed over a profiled sheet. The overall thickness of slab is 350-500mm. The I-section member has been placed at end of the slab width act as a girder. Sub structure consists of pile foundation. Pier cap is 600mm deep. The length of pile is 6m. Each column has four piles and the safe bearing capacity of soil is 300KN/m^2.

3. DESCRIPTION OF THE MATERIALS

3.1 Steel

Steel of I Section is adopted for the Deck Slab design and composite circular tube adopted for Pier design.

4. LOADS ON THE STRUCTURE

4.1 DEAD LOADS

The dead loads of the structure consists of the self-weight of the various components such as deck slab, intermediate girders, cross girders, pier (columns).

4.2 LIVE LOADS

The bridges loads can be assigned in the form of moving loads and impact loads, IRC: 6-2014 is used to verify all values. The governing loading is:

Class AA Wheeled Vehicle

4.3 VEHICLE LOAD

Vehicles are defined for Class AA Wheeled in accordance to IRC 6, 2014.

5. DESIGN STRUCTURES

Obligatory span is the central most portion of the fly-over. A minimum vertical clearance of 10m is allotted for the obligatory span

5.1 Beam Design

Length of the span	=	10m
Dead load of P.C.C Slab	=	30.24 KN/m
Dead load of steel plate	=	0.314 KN/m
Live load (vehicle)	=	36 KN/m
Live load	=	2 KN/m
Total load	=	68.554 KN/m
Factored load	=	102.83 KN/m
Bending Moment	=	$102.83 \times 10^2 / 8$
	=	1285.3875 KNm
To find z_p	=	$M_U \times \gamma_{mo} / f_y$
	=	2570.775×10^3 mm^3.

Section Properties

Refer sp-6 I-section		
Weight	=	145.1 Kg/m
Cross sectional area	=	184.86 cm^2
Depth of section	=	600mm
Width of section	=	250mm
Thickness of flange	=	23.6mm
Thickness of web	=	11.8mm
Moment of inertia	=	115626.6×10^4 mm^4
Radius of gyration	=	53.5mm
Dead load of section	=	1.45 KN/m
Factor load of section	=	2.175 KN/m

Total load = 105 KN/m
Check for Buckling b/t_f = 250 /(2 x 23.6)
= 5.29 < 9
43.79 < 67
Hence it's safe for buckling, not required for buckling
Shear force: = wl/2
= 105 x 10 / 2
= 525 KN
Bending moment = $wl^2/8$
= $105 \times 10^2/8$
= 1312.5 KNm
= 4.05 mm

5.2. COLUMN DESIGN

Total load = 1728KN
Factor load = 2592KN
Find the section and properties
Assume buckling class "a" (Hot Rolled Steel Tube)
α = 0.21
Refer Table IS 800 table "9a" f_{cd} values,
Refer member properties IS 1161 table 1
Hot Rolled Steel Tube properties:
NB = 350mm
OD = 355.6mm
T = 12mm
Mass = 101.68 kg/m
Area of cross section = $129.53 cm^2$
Moment of Inertia = $19139.47 cm^4/m$
Modulus of section = $1076.46 cm^3$
Radius of gyration = 12.16cm
Buckling class "a" α = 0.21
Along y-y axis Kl/r = 37
Refer Table IS 800 table "9a"
f_{cd} = 215.1
P_d = $f_{cd} \times A_e$
= 2786.2×10^3 KN

5.3. Pile Design

Total load = 2518 KN
Length of Pile = 6m
Grade of concrete f_{ck} = $40 N/mm^2$
Yield strength of steel f_y = $500 N/mm^2$

Main Reinforcement:
h/D = 6/0.3
= 22 < 12
Since this is greater than 12, the pile behave as a long column,
Hence, Reduction co-efficient
= $1.25 - l_{ef}/48D$
= 0.79
P_u = 1.5 x 2518 / 0.80
= 4721.25 KN

A_{sc} = 4951.9 mm
Since the length of pile is less than 30 times the width, minimum reinforcement 1.2% of gross cross sectional area
= $1.2/100 \times \pi \times 500^2/4$
= $2454.7 mm^2$
Provide 5 bars of 25mm ϕ bars,
Nominal cover of 50mm, assume stirrups 8mm ϕ bar, cover centre of reinforcement is,
= 50+8+25/2
= 70.5 mm

Lateral reinforcement in the body of the pile:

Lateral reinforcement in the body of the pile is provided at 0.2 % of gross volume
Volume needed per m length
= $0.2/100 \times \pi \times 500^2/4 \times 1$
= $392 mm^3$
Nominal cover of 50mm, assume stirrups 8mm ϕ bar,
Length of each side of tie = 500 – 2 x 50 – 8
= 392 mm
Area A_p = $\pi \times 8^2/4$
= $50.3 mm^2$
Volume of each tie = π x 392 x 50.3
= $61944.66 mm^3$
Pitch = 61944.66/392
= 158 ~ 160 mm
Maximum pitch permissible
= 1/2 x 500
= 250 mm
Hence provided 8mm ϕ ties at 160 mm c/c throughout the length of the pile.

Lateral reinforcement near pile cap:

Near pile head, special spiral reinforcement provided, volume of spiral at 0.6% of gross volume
Per m length is = $0.6/100 \times \pi \times 500^2/4 \times 1$
= $1176 mm^3$
Use 8 mm ϕ spiral, A_p = $50.3 mm^2$
Pitch, S = π x 392 x 50.3/1176
= 52.6 ~ 55 mm

Lateral reinforcement near pile end:

Volume of tie per metre length 0.6 % of gross volume
= 960mm
Volume of each tie = $61944.66 mm^3$
Pitch, S = 52.6 ~ 55 mm

Spacer forks and links:

Provide 2 pair of 12 mm ϕ spacer fork with 6mm ϕ links at 1.5 m c/c along the length.

Check for moment resistance:

One hole at 1^{st} end 0.293

$L = 0.293 \times 6.6$

$= 2$ m

One hole either end 0.206

$L = 0.206 \times 6.6$

$= 1.36$ m

Weight of pile $= \pi \times 500^2 \times 25 / 4$

$= 4900$ N/m

$M = 4900 \times 2^2 / 2$

$= 9800$ N/m

$M_u = 14.7 \times 10^6$ Nmm

Effective depth of pile section

$= 500 - 70.5$

$= 429.5$ mm

$X_{u\,max} = 0.479$ D

$= 205.73$ mm

$X_u = 0.5 \times X_{u\,max}$

$= 102.86 \sim 105$ mm

$A_{sc} = 2 \times \pi \times 25^2 / 4$

$= 981.7\ mm^2$

$\varepsilon_{sc} = 0.0035 \times (X_u - d^1) / X_u$

$= 0.00115$

$f_{sc} = E_s \times \varepsilon_{sc}$

$= 230\ N/mm^2$

$= 964286$ N

$T_u = 0.87\ f_y\ A_{sc}$

$= 427039.5$ N

$C_{ru} = 756000$ N

$C_{su} = 214291$ N

$M_{ur} = 368.7 \times 10^6$ Nmm

6. ANALYTICAL DESIGN

The analysis and design of flyover is done by STAAD Pro V8i. This software used to design composite beam, pier and the results are taken out.

6.1 Beam Reports

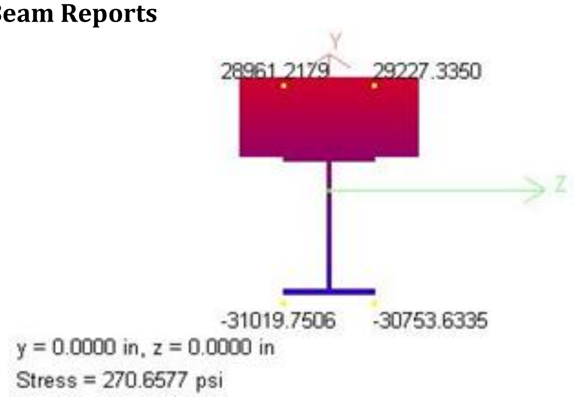

Fig -2: **Stress in Composite Beam Cross Section**

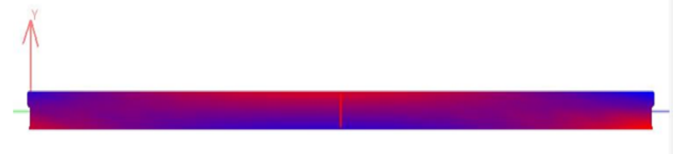

Fig -3: **Stress in Composite Beam Longitudinal Section**

Table -1: Stress in Beams

S. No.	Members	Top portion	Bottom portion
1.	Longitudinal beam	-10399.6377 -10399.0164	10064.4665 10059.0878
2.	Cross sectional beam	-32919.8532 -32915.5579	31856.0886 -31857.69
3.	Mid sectional beam	-31637.6019 -31611.4063	30578.5961 30604.7916

6.2 Column Reports

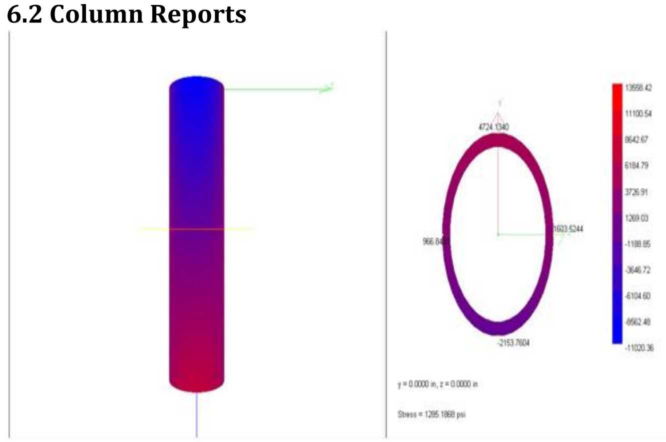

Fig -4: **Stress in Column**

Table -2: Stress in Column

S. No.	Member	Top portion	Bottom portion
1.	Column or pier	8668.0250 8658.0439	8657.6986 8668.3702

6.3 Bending Moment

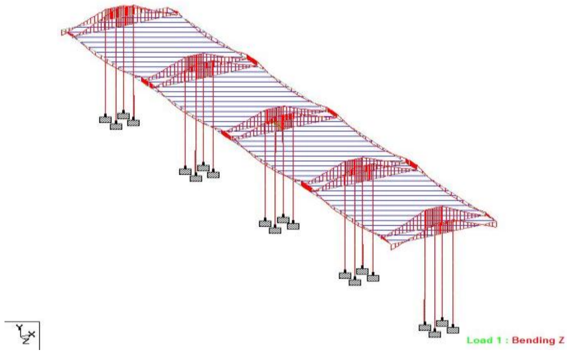

Fig -5: Due to Self Weight

Live Load:

2KN/m for during construction process. This type of load can be assigned to super structure. 2KN/m for parapet wall load. It assigned end of the beams only.

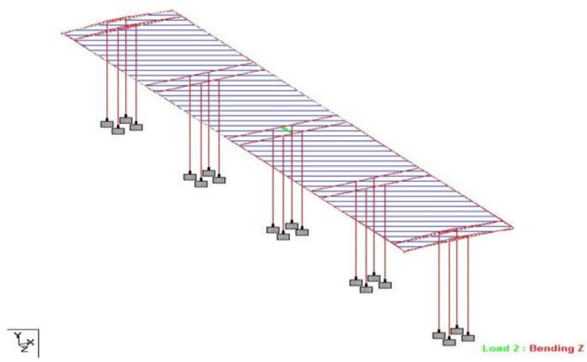

Fig -6: Due to Live Load

Vehicle Load:

Vehicle load is taken as 720 KN from IRC Class AA. The pressure is 7.523 kg/cm^2 for single axle pressure. Overall slab pressure is 20.57 KN/m^2.

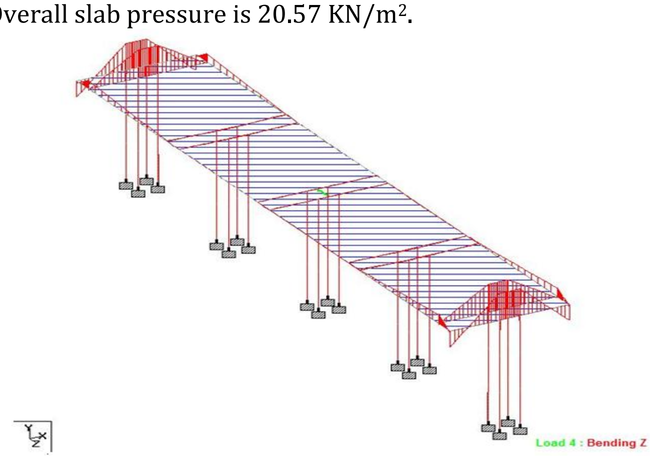

Fig -7: Due to Vehicle Load

Load Combination 1:

Load combination based on Indian standards. 1.7+1.7+1.7+1.7

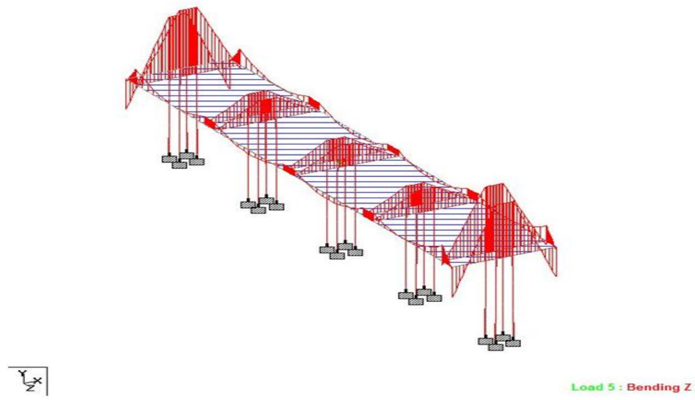

Fig -8: Due to Load Combination 1

Load Combination 2:

Load combination based on Indian standards. 1.7 For only self weight of the structure.

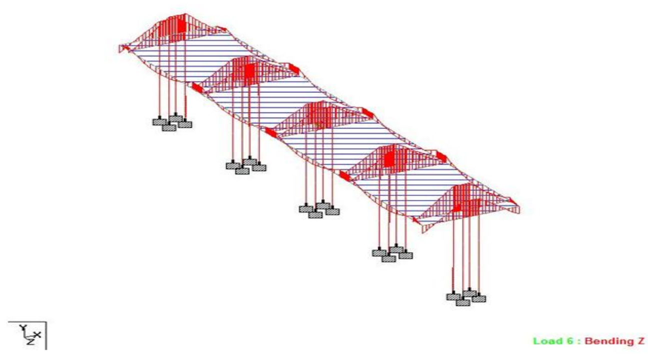

Fig -9: Due to Combination Load 2

Load Combination 3:

Load combination based on Indian standards. 1.7+1.2+1.7+1.7

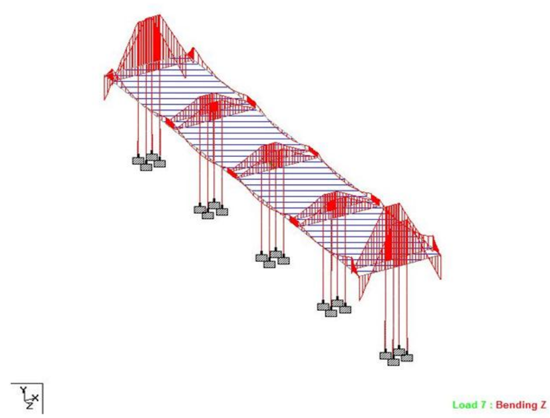

Fig -10: Due to Combination Load 3

7. RESULT

7.1. Beam Result

Longitudinal Beam

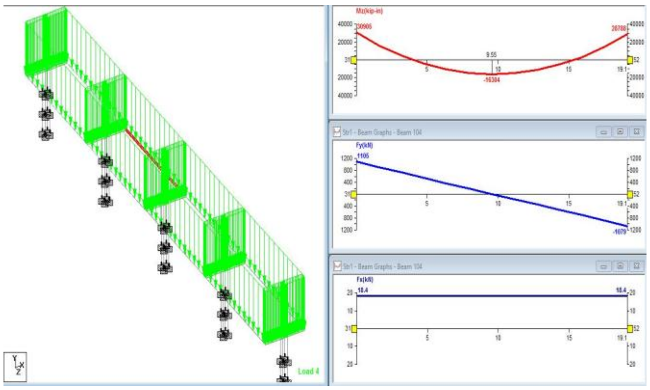

Fig -11: Longitudinal Beam

Cross Sectional Beam

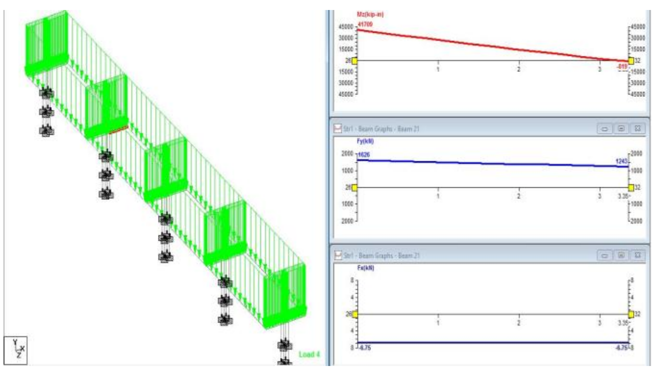

Fig -12: Cross Sectional Beam

Mid Sectional beam

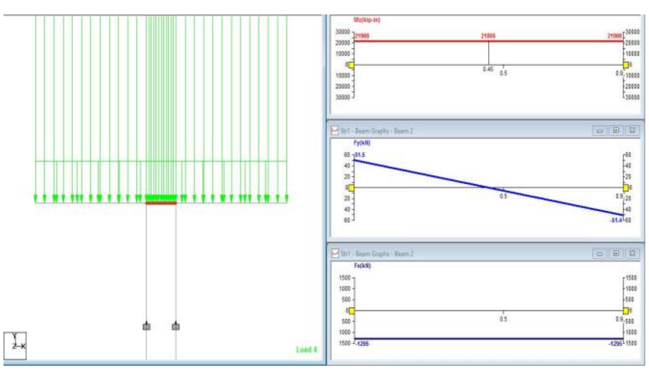

Fig -13: Mid Sectional Beam Results

Table No. 3. RESULTS OF BEAM

S. No.	Members	Bending Moment KN-m	Shear Force KN	Deflection Mm
1	Longitudinal Beam	3553.20 3085.06	- 277.747	0
2	Cross Sectional Beam	10805.88 10963.78	-56.134	0
3	Mid Sectional Beam	11667.66 890.57	352.30 0	0

7.2. Column Result

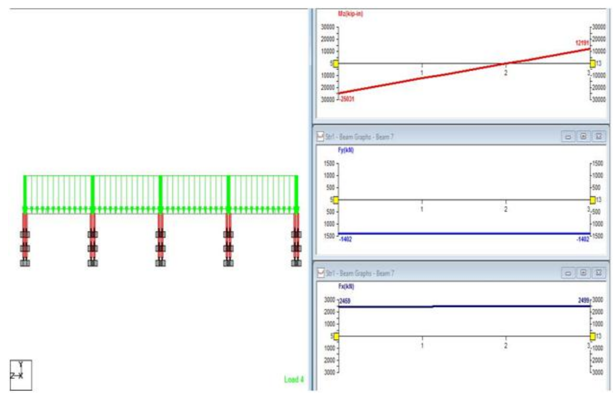

Fig -14: Column Results

8. CONCLUSION

The main purpose of our research is to construct flyover using steel sections since the construction of R.C.C flyover is time consuming, it will affect existing traffic. Even though its initial cost is high the steel bridges offer wide range of solutions to choose based on the design / site requirements. It is done in Fast track construction. It is helpful to the urban area for minimum disruption and prefabrication possibility. It is easy to construct, maintain and reduce the cost of construction. By using sleek, strong and long span structures, it became lighter foundation. Due to improvisation of life cycle performance, it has been durable and long life in structures and also ensured that the quality of material and construction of the structure. By using Steel structural members the self weight of the structure has been comparatively reduced.

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