Seismic Behavior of Steel-Concrete Composite Structures

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ABSTRACT---Steel-Concrete composite individuals are an intriguing alternative for auxiliary originators, yet the dependability of plan strategies both on account of gravity and seismic burdens is in persistent advancement. Composite steel-concrete design gives a noteworthy economy through decreased materials and quicker development, such framework utilizes each kind of part in the most proficient way to expand the basic and financial advantages. In this undertaking, hypothetical, numerical perspectives and applications concerning the seismic conduct of steel-concrete composite structures are to be dissected.

The intrigue has been concentrating around there on the capacity of composite encircled structures to disseminate seismic vitality by methods for inelastic disfigurements with the goals to:

(1) Apply non-direct investigation strategies to assess building execution.

(2) The chief highlights influencing the seismic reaction of composite edges.

(3) A numerical examination has been direct to research the impact of composite conduct of the structures.

(4) A limited component modular has been create to represent the dynamic conduct of composite structure and (5) The impact of shear connector on the conduct of composite encircled structure in seismic stacking.

Keywords: Steel-concrete, seismic loading, gravity, composite structure, seismic response, finite element modal, composite behavior.

I. INTRODUCTION

The most significant and most habitually experienced blend of development materials is that of steel and concrete, with applications in multistory business structures, industrial facilities, and infrastructures. The essential head fundamental composite development is that sure materials might be utilized all the more adequately in particular sorts of focused on conditions; consequently, the mix of material solid in pressure with one in number in strain makes an exceptionally conservative association for its utilization in structures. With essential materials, for example, solid, steel, stonework materials, wood, and timber, various viable mixes can be utilized. These basically various materials are totally good and corresponding to one another; they have nearly a similar thermal expansion; they have a perfect mix of qualities with the solid product in pressure and steel in strain; concrete likewise gives corrosion protection and thermal insulation to the steel at the raised temperatures and furthermore can limit slim steel areas from local or lateral buckling.

In multistory structure, structural steelwork is regularly utilized together with concrete; for instance, steel beams with concrete floor slabs. The equivalent applies to the Bridges, where solid decks are typically liked. A further increasingly significant thought is that the utilization of rolled steel segments, profiled metal decking as well as pre-assembled composite individuals accelerate execution. And furthermore, composite floor development is profoundly focused if ranges are expanded to 12 to 15m or even 20m.

- Composite beams, subject for the most part to twisting, comprise of a steel segment acting totally with one (or two) spines of reinforced concrete the two materials are interconnected by methods for mechanical shear connector. In the event that slip is allowed to happen at the interface between the steel area and the solid chunk, every part will act freely. The accompanying suppositions are typically used for the definition of the fundamental composite plane edge investigation (Vallenilla, 1987). It is underscored that nonlinear investigation systems, for example, those used to assess unadulterated steel casing and fortified solid edge conduct, can be applied to composite edges too.
- The building is a rectangular lattice design. Story stature may change self-assertively, as May the inlet widths toward every path. Be that as it may, it is accepted that the columns stretch out constantly from base to top and the supports from side to side. The steel has a straightly versatile consummately stress-strain relationship.
- The members are straight, prismatic and symmetric about the plane of the frame. Loads are applied in the plane of the frame, and only at the end of the elements. Only in-plane deformations are considered.
- Only 50% of the solid cross-area remains uncracked after the composite segments are stacked.
- Slip doesn't happen among steel and cement and no Parallel Torsional clasping.

II. METHOD OF ANALYSIS BY EUROCODE 4

Euro code 4 *Design of composite steel and concrete structures* will consist of three parts:

Part 1 - General Rules and Rules for building, Part 2 – Bridges & Part 10 - Fire Resistance

3D Steel Beam Analysis:-

Shell elements (SHELL43) have been used in beam modeling. The element shell 43 is defined by four nodes having six degrees of freedom at each node & Ansys Finite element mesh (shell 43) as shown in Fig 1 & Fig 2. The deformation shapes are linear in both in-plane directions. The element allows for plasticity, creep, stress stiffening,

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and large deflections and large strain capabilities. The Von-Mises yield criterion with isotropic hardening rule is used to represent the steel beam behavior.

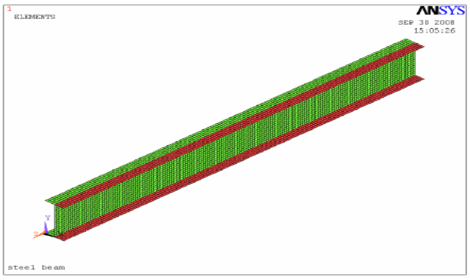

Fig.1 Ansys Finite element mesh (Shell 43)

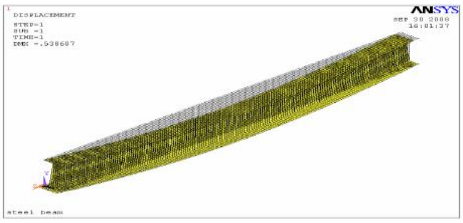

Fig.2 Ansys Finite element mesh (Shell 43)

The results of the analysis performed in Ansys has compared with the deflections obtained from the analysis done by SAP 2000 & ANSYS with load in KN/m are shown in the Table I & results comparison for the steel beam with Ansys & sap are shown in Fig 3.

Table-I: Analysis results for the steel beam ISMB 500.

Load in KN/m	ANSYS	SAP
10	0.538	0.547
11	0.592	0.601
12	0.646	0.656
13	0.700	0.687
14	0.754	0.732
15	0.807	0.795
16	0.861	0.852
17	0.915	0.901
18	0.969	0.932
19	1.023	1.0192
20	1.077	1.093

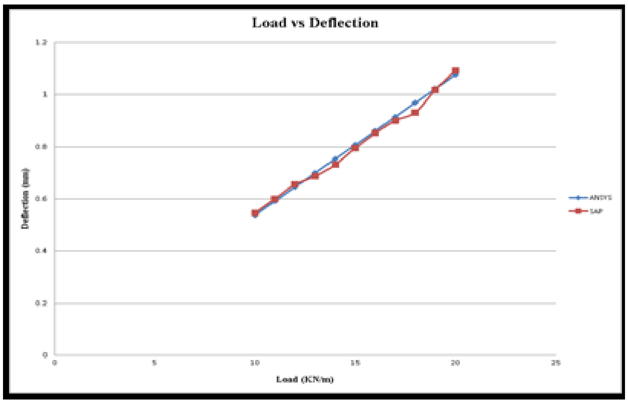

Fig 3 Results comparison for the steel beam with Ansys & sap

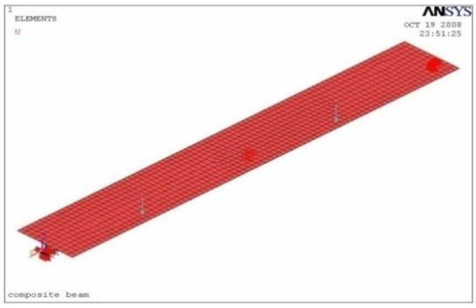

Fig. 4 Ansys modeling for the composite beam analysis

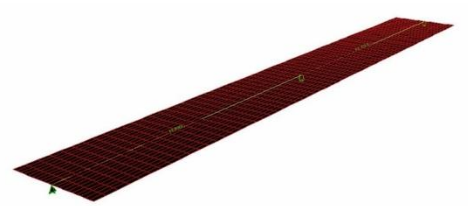

Fig. 5 Sap modeling for the composite beam

Analysis Results:-

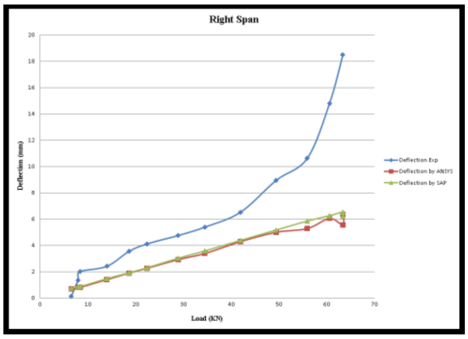

Fig 6 Analysis for the right span of the composite beam

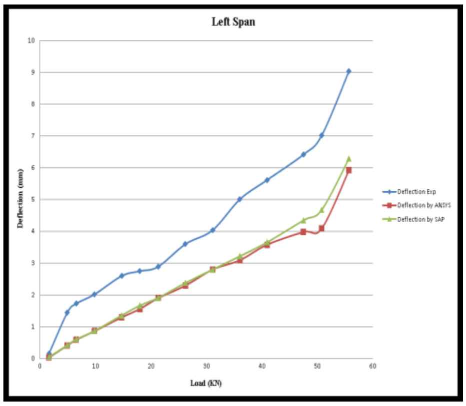

Fig 7 Analysis for the left span of the composite beam

Discussion:

In the experimental analysis composite beam, there was a partial shear connection between steel and concrete due to which the experimental deflection was found more & Ansys /sap modeling for the composite beam analysis for left & right are shown in the Fig 4,5,6 & 7 than the theoretical deflection with the full shear connection is assuming in the calculation.

III. ANALYSIS OF RESIDENTAL BUILDING

In this part of the report, G+3 residential building is considered. It is analyzed using STAAD Pro software. The Architectural plans, typical beam layout given to STAAD software is been shown in figures. The architectural plan of the building is shown in the figure. The plan dimensions of the building are 9.38 x 11.38m. The building is completely residential. The height of the building is 10.1m. Design the column and beam with the analysis results and made comparisons (Weight and cost) with the RCC design.

Loading considered for the analysis:-

Architectural plan of the residential building as shown in Fig 8. Where the dead load and live load have been considered based on the IS: 875 (part 2)

PLAN

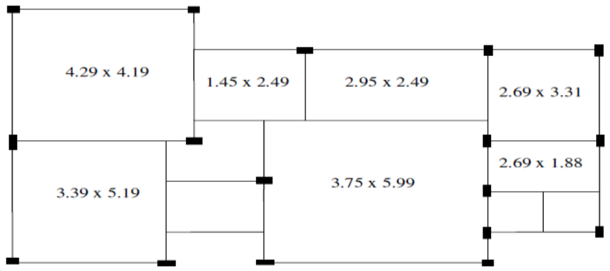

Fig 8 Architectural plan of the residential building

RESULTS OF THE ANALYSIS:

The column end moments and beam maximum moments are shown in Table II and Table III

Table –II: Column end moments

Column	Node	Axial	Shear		Moment	
		KN	F_y	F_z	M_y	M_z
1011	2011	1.15E 3	15.802	23.261	-0.000	0.000
	11	*-1.15E 3*	*-15.802*	*-23.261*	*-32.566*	*22.123*
1013	2013	784.098	-20.348	-15.382	-0.000	0.000
	13	-784.098	20.348	15.382	21.535	-28.487
1014	2014	1.01E 3	5.445	1.496	-0.000	-0.000
	14	-1.01E 3	-5.445	-1.496	-2.095	7.624
1017	2017	935.789	32.484	1.719	0.000	0.000
	17	-935.789	-32.484	-1.719	-2.407	45.478
2011	11	798.380	15.329	22.972	-33.028	21.916
	111	-798.380	-15.329	-22.972	-33.590	22.537
2017	17	658.205	31.736	2.133	-2.976	43.398
	117	-658.205	-31.736	-2.133	-3.209	48.637
2021	21	507.977	-15.547	3.569	-5.547	-20.565
	121	-507.977	15.547	-3.569	-4.804	-24.521
3011	111	444.617	13.777	21.710	-32.663	20.129
	211	-444.617	-13.777	-21.710	-30.296	19.825
3013	113	305.515	-18.818	-13.491	20.507	-28.456
	213	-305.515	18.818	13.491	18.618	-26.117

Table- III: Beam maximum moments

Beam	Node A	Length (m)		d (m)	d (m)	Max Mz (kNm)
8	11	3.390	Max -ve	3.390	0.000	72.346
			Max +ve	0.000	2.260	-94.358
11	16	1.550	Max -ve	1.550	1.550	105.448
			Max +ve	0.000	0.000	0.000
19	26	5.190	Max -ve	0.000	5.190	138.604
			Max +ve	5.190	2.163	-86.403
28	25	2.790	Max -ve	2.790	2.790	90.598
			Max +ve	0.000	0.465	-53.551
108	111	3.390	Max -ve	3.390	0.000	73.599
			Max +ve	0.000	2.260	-99.635
111	116	1.550	Max -ve	1.550	1.550	109.392
			Max +ve	0.000	0.000	0.000
119	126	5.190	Max -ve	0.000	5.190	135.870
			Max +ve	5.190	2.163	-88.441
129	117	1.950	Max -ve	0.000	0.000	99.183
			Max +ve	1.950	1.950	0.000
219	226	5.190	Max -ve	0.000	5.190	107.868
			Max +ve		2.163	-72.142

COMPARISON AND CONCLUSION:

- The deadweight of structure is found to be much lesser than (15.7%) that of RCC building
- The most important benefit of composite column is that it has more flexural stiffness than the RCC sections, Due to this increased stiffness(increased to 1.7%) the composite column experience less deflections than the RCC column
- The Effective utilization of material viz. concrete in compression and steel in tension (Cost is reduced to 9%)
- In a composite structure, the self-weight of the frame is less and therefore substantial gain in the cost of the foundation.

IV. SEISMIC PROVISIONS FOR COMPOSITE STRUCTURES

SEISMIC ANALYSIS OF COMPOSITE FRAME SYSTEM

So as to fig 9 the seismic strength of the composite casing a middle of the intermediate composite floor upheld with steel segment is considered and the breaking down the edge to modular, consonant, transient and range investigation. In the course of the most recent couple of years, the dynamic conduct of the composite floor frameworks has been tentatively and logically explored by different creators. These examinations have utilized current computational apparatuses for auxiliary investigation with the guide of limited component technique. The utilization of steel-concrete floor frameworks offers a few social handy preferences overexposed steel and different choices. The expansion of solidness and limit of composite activity empowers the utilization of enormous shaft ranges under similar stacking conditions. As far as seismic execution, composite edges display ideal conduct because of the upgraded reaction qualities including malleability properties.

Computational model:-

The proposed computational model, produced for the composite floors dynamic investigation, utilized the standard work refinement procedure present in limited component technique recreations actualized in the ANSYS program. In this computational model, the floor steel braces are spoken to by three-dimensional bar components (BEAM4) considering flexural impacts. The solid piece is made of shell limited components (SHELL43 versatile plastic shell). What's more, to recreate the conduct of headed stud shear connectors, COMBINATION39 (Non-direct spring) components from the ANSYS 9 library have been utilized.

Dynamic analysis:

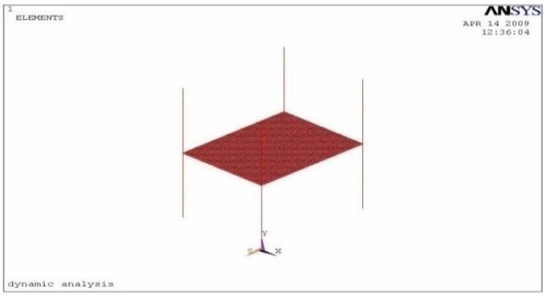

Fig 9 Ansys model for the analysis

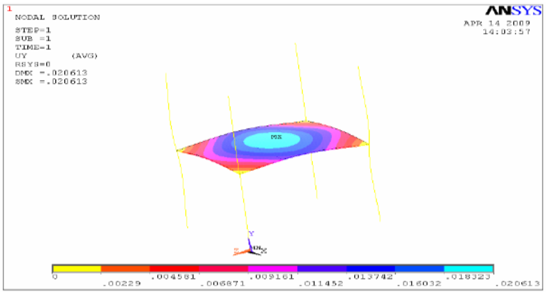

Fig 10 Stress contour in the Harmonic Analysis

For useful purposes, a direct time-area examination was performed all through this investigation. This displays the assessment of the composite floor vibration levels when submitted to dynamic excitations delivered by human strolling as shown in fig 10. The composite floor's dynamic reactions were resolved through an examination of its characteristic frequencies, relocations, speeds, and increasing velocities as shown in fig 11 & 12. The aftereffects of the dynamic investigation were gotten from a broad parametric examination, in view of the limited component technique utilizing ANSYS. For the non-linearity in the stud, a standard experimental condition of Yam and Chapman's heap slip condition is considered. With the end goal of current examination the constants an and b were expected equivalent to 30 kN and 5.0 mm separately.

ANSYS RESULTS:

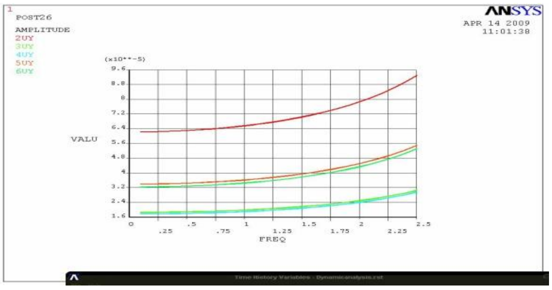

Fig 11 Frequency response of composite frame system with salient points

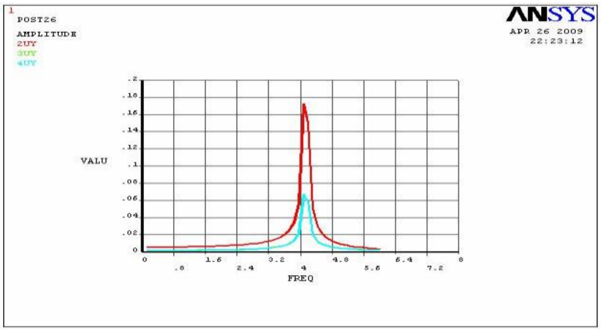

Fig 12 Harmonic response of composite frame system

TRANSIENT DYNAMIC ANALYSIS:

Transient dynamic analysis (sometimes called time-history analysis) is a technique used to determine the dynamic response of a structure under the action of any general time-dependent loads.

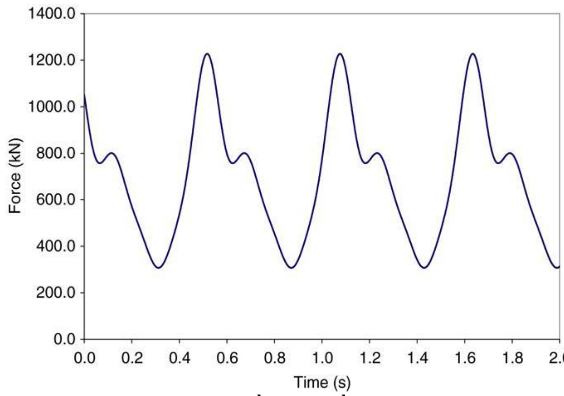

Fig 13 2nd and 3rd Model

In this type of analysis to determine the time-varying displacements, strains, stresses, and forces in a structure as it responds to any combination of static, transient and harmonic loads as shown in fig 13 & 14.

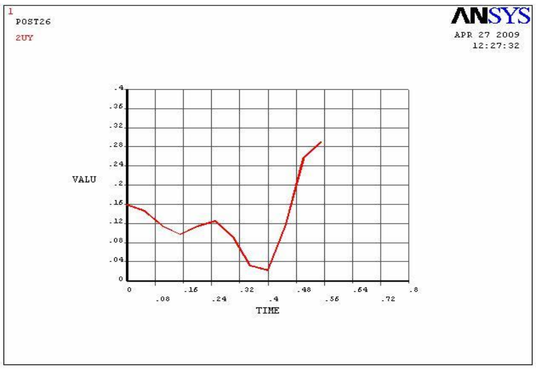

Fig 14 Transient Response for the frequency of 0.55Hz

SPECTRUM ANALYSIS & RESULTS

A range investigation is one in which the consequences of a modular examination are utilized with a realized range to ascertain relocations and worries in the modular, it is primarily utilized instead of a period history examination to decide the reaction of a structure to arbitrary or time-subordinate stacking conditions, for example, seismic tremors, wind loads, machine vibrations, etc. As appeared in fig 15 underneath stoop spectra with damping level of 5 is utilizing for the examination of the composite casing framework. The Ansys results for spectrum analysis i.e: the reaction forces and nodal displacements at salient points are given in Table-IV and Table-V respectively.Furthermore, these outcomes are contrasted and the manual aftereffects of reaction range investigation yet not introduced here.

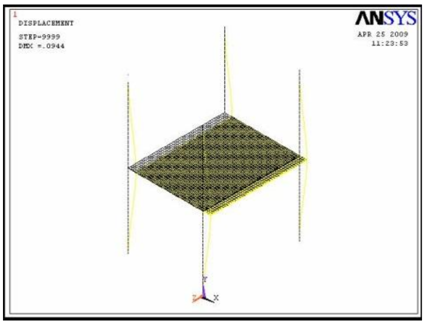

Fig 15 Deflected shape in the Ansys spectrum analysis

Ansys results for the spectrum analysis:

Table –IV: Reaction forces:

Node	FX	FY	FZ	MX	MY	MZ
1	29058	184.86	8.2417	38.856	70.451	1.02E+05
27	29059	184.78	4.5274	25.757	74.563	1.02E+05
53	29059	184.78	4.5232	25.754	74.634	1.02E+05
79	29058	184.86	8.2374	38.853	70.598	1.02E+05
113	28800	61.628	24.585	76.986	47.028	1.01E+05
133	28800	61.558	20.701	63.491	52.742	1.01E+05
153	28800	61.558	20.718	63.537	52.982	1.01E+05
173	28800	61.628	24.602	77.032	47.101	1.01E+05

Table –V: Nodal Displacements at Salient Points:

NODE	UX	UY	UZ	USUM
2	9.41E-02	7.89E-07	1.72E-05	9.41E-02
28	9.41E-02	7.88E-07	1.33E-05	9.41E-02
54	9.41E-02	7.88E-07	1.33E-05	9.41E-02
80	9.41E-02	7.89E-07	1.73E-05	9.41E-02
105	9.42E-02	2.65E-07	1.74E-05	9.42E-02
107	9.42E-02	2.64E-07	1.34E-05	9.42E-02
109	9.42E-02	2.64E-07	1.35E-05	9.42E-02
111	9.42E-02	2.65E-07	1.74E-05	9.42E-02
210	9.42E-02	7.13E-07	1.07E-06	9.42E-02
316	9.42E-02	7.13E-07	1.30E-06	9.42E-02
353	9.44E-02	6.55E-05	2.32E-06	9.44E-02
355	9.44E-02	6.54E-05	8.69E-07	9.44E-02
395	9.44E-02	6.55E-05	2.32E-06	9.44E-02
438	9.42E-02	6.60E-05	3.16E-06	9.42E-02
478	9.42E-02	7.15E-07	6.71E-08	9.42E-02
517	9.42E-02	6.60E-05	3.15E-06	9.42E-02
1304	9.42E-02	1.24E-07	6.08E-08	9.42E-02

Discussions:

The target of this examination has been the examination of the seismic presentation of composite moment frames with full and incomplete shear association exposed to seismic stacking.

The plan of structures in seismic districts is regularly constrained by sidelong solidness required to restrict the greatest understory floats beneath the most extreme permitted by the code. Henceforth it is especially critical to inspect, how sidelong disfigurement requests are evaluated in seismic arrangements.

Reaction adjustment elements, R and redirection intensification factor Cd to be utilized for various seismic power opposing frameworks is table 8.1. It can be seen that reaction change variables differ from 3.0 for respectably pliable opposing frameworks, for example, standard composite minute casings to 8.0 for malleable opposing frameworks, for example, unique composite minute edge structures or composite concentrically supported frameworks. Diversion intensification factor shifts from 2.5 for reasonably bendable opposing frameworks, for example, normal composite minute edges to 5.5 for malleable opposing frameworks, for example, extraordinary composite minute edge structures.

V. CONCLUSIONS

1. The primary explanation behind this inclination is that the segments and individuals are most appropriate to oppose rehashed seismic tremor loadings which require a high measure of restriction and pliability.
2. The steel individuals are generally vulnerable against the compressive powers. Anyway, the mix with the concrete can enormously improve the bending moment because of the fact that the concrete limits the abundance locking of steel individuals in pressure.
3. The composite flexural strength of composite slim floor shafts can be determined by the plastic method (the supposed rectangular stress block method).
4. The flexural firmness of the composite slim floor bars ought to be taken as that of the split areas.
5. Comparison with the test information for simply supported composite beams demonstrates that the coding

technique brings about a satisfactory degree of the security for degrees of shear association, not exactly the predetermined least.

6. In the dynamic examination of reinforced concrete slabs with steel beams with deformable association was normal that the augmentation of the eigenfrequencies with the addition of the connector's firmness is effectively checked.

7. The dependability and the adequacy of the methodology for nonstop shafts, which permits acquiring both worldwide parameters, for example, revolutions and redirections just as amounts, for example, rotations and deflections as well as quantities such as slips, curvature, interaction forces, and rebar strains, can be stretched out additionally to semi-continuous beams.

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