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Comparative Seismic Analysis of Composite Structures and RCC Structures

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ABSTRACT: High-rise structures are becoming very common everywhere due to scarcity of land and increasing population. Though we have RCC structure system as high rise building but in RCC building due to bulky size of components of structure, self-weight will be more due to heavy density of materials. By observing the difficulties and challenges in the field of high-rise structures engineers are using efficient structural system that is, steel concrete composite structure. Composite structure consists of composite deck slab, composite beam and composite column. Composite structure compiles of concrete which is good in compression and structural steel which is good in tension and composition of these materials makes structure better in ductility which comparatively higher side of RCC structure. G+8 high-rise structure is considered for analysis by ETABS software. This analysis of commercial building by response spectrum method on composite structure and RCC structure with same plan and building of same design data. Analytical comparison of both composite and RCC frame based on structural parameters are made with help of graphs and tables. By comparing the results, found composite structure are more desirable than RCC structures.

KEYWORDS: Composite Structure, Seismic Analysis, G+8 Building, ETABS Software, RCC Building, Composite Building.

I. INTRODUCTION

In the old era the design of a building, the choice was normally between a concrete structure and a masonry structure. But the failure of many multi-storied and low-rise R.C.C. and masonry buildings due to earthquake has forced the structural engineers to look for the alternative method of construction. Use of composite or hybrid material is of particular interest, due to its significant potential in improving the overall performance through rather modest changes in manufacturing and constructional technologies. As per IS 11384 the composite construction consists of the use of prefabricated structural units like steel beams, precast reinforced or prestressed concrete beams in combination with in-situ concrete. The construction should ensure monolithic action between the prefabricated and in-situ components so that they act as a single structural unit. These essentially different materials are completely compatible and complementary to each other; they have an ideal combination of strengths with the concrete efficient in compression and the steel in tension. In composite construction, composite slab is defined as a slab system comprising normal weight or lightweight structural concrete, placed permanently over cold-formed steel deck in which the steel deck performs dual roles of acting as a form for the concrete during construction and as positive reinforcement for the slab during service. A composite beam is formed by a reinforced concrete slab attached to the upper flange of a hot-rolled or welded steel beam by shear connectors so that they act together as a single section. A steel-concrete composite column is comprising of either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load bearing member in a composite framed structure. With the use of composite column along with composite decking and composite beams, it is possible to erect high-rise structure in an extremely efficient manner. In the present work, for the design of each building component a separate software is developed with pre-, main- and post- processing facilities in VB.NET based on IS code (1985, 2000) and Euro code (2004). The calculation of the limit state of different types of composite structural elements is considered. All principal design checks are incorporated in the software. The full and partial shear connection and the requirement for transverse reinforcement are also considered. To facilitate direct selection of steel section, a database is prepared and is available at the back end with the properties of all standard steel sections.

This study involved two stages. The primary data was gathered through a Literature survey targeted by review of e books, manuals, codes and journal papers. After review, the problem statement is defined and 2 models are taken up for detailed study and analysis.

Objective of study:

1. To study the seismic response of composite and RCC multi-storeyed structures.
2. To Analyse Composite sections for dynamic forces in FEM Software ETABS.
3. To compare time period of different modes for RCC and composite structure.
4. To compare natural frequency of different modes for RCC and composite structure.

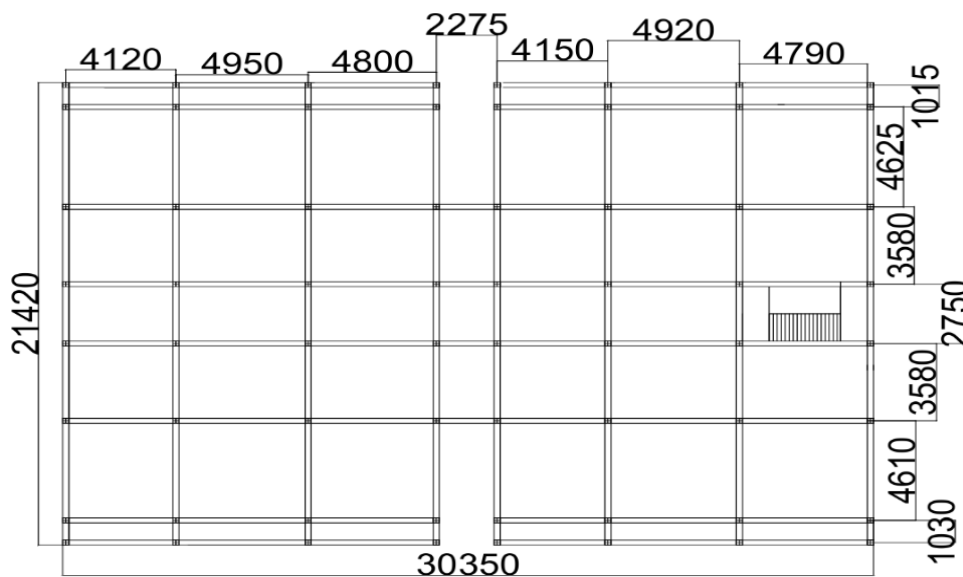
II. METHODOLOGY

MODEL DETAILS

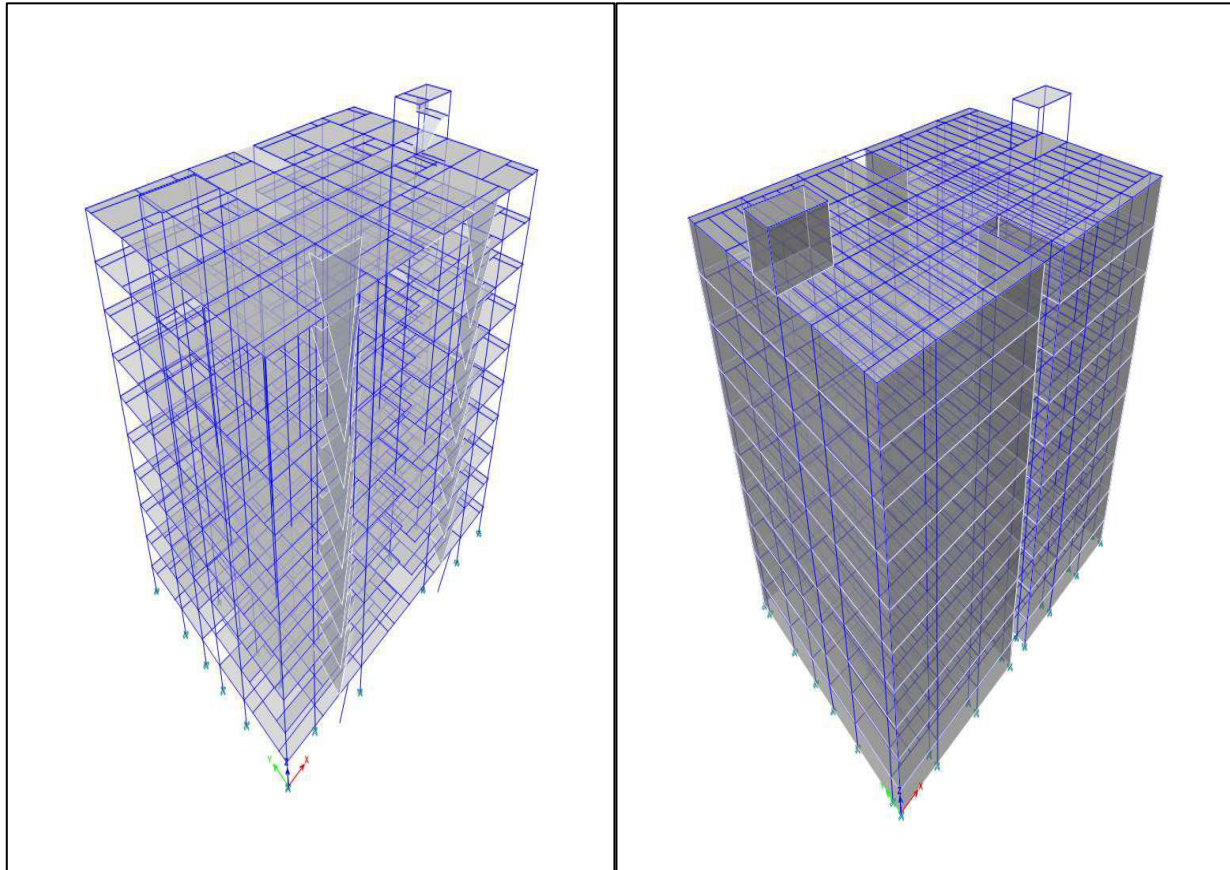
Model 1	RCC STRUCTURE
Model 2	COMPOSITE STRUCTURE

MODEL DETAILS

Sr. No.	Parameter	Values
1.	Number of storey	G+8
2.	Base to plinth	1.5 m
3.	Floor height	3m
5.	Materials	Concrete M25 and Reinforcement Fe 500
8.	Size of column	400mm x 800 mm
9.	Size of beam	230mm x 600 mm
10.	Depth of slab	125 mm



Plan of Building
Note: All dimensions are in mm.



Model 1: RCC Structure

Model 2: Composite Structure

LOAD DETAILS

a.	Dead load	In ETABS the software itself calculates the dead loads by applying a self-weight multiplier factor of one which is taken by the structure and the rest load cases are kept zero. Its defined in the load cases section.
b.	Live load on roof and floors	2 kN/m ² and 4 kN/m ² as per IS:875 (part -2)
c.	Floor finish on roof and floors	1.5 kN/m ² as per IS:875 (part -2)
d.	Wall load on all levels	7.8 kN/m

SEISMIC DATA REQUIRED FOR ANALYSIS

Sr. No.	Parameter	Values as per IS 1893:2016 (Part1)	Reference
1.	Type of structure	Special RC moment resisting frame	Table 9, Clause 7.2.6
2.	Seismic zone	V	Table 3, Clause 6.4.2
3.	Location	Delhi	Annex E
4.	Zone factor (Z)	0.36	Table 2, Clause 6.4.2
5.	Type of soil	II	Clause 6.4.2.1
6.	Damping	5 %	Clause 7.2.4
7.	Response reduction factor (R)	5	Table 9, Clause 7.2.6
8.	Importance factor (I)	1	Table 8, Clause 7.2.3

III. STUDY RESULTS

1. For Time Period

After analysing the model, the time period value is obtained. The time period value is also obtained manually from the formula provided in IS code (IS 1893(part1):2002). The values obtained from software and from the IS code is studied and the results are depicted in the graphs considering various parameters such as beam ratio, column ratio, number of bays.

Table 1 Time Period Comparison

Mode	Time Period	
	RCC	Composite
1	1.214	0.719
2	0.664	0.609
3	0.647	0.594
4	0.382	0.234
5	0.368	0.2
6	0.364	0.195

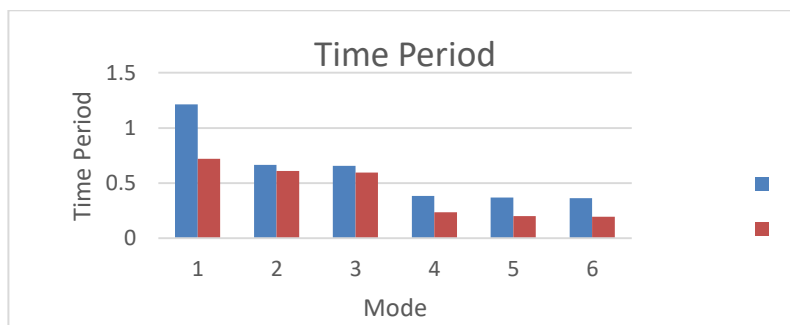


Fig 1. Time Period Graph

From the above table & graph, observe that percentage variation for dynamic analysis time period for model 2 is less than model 1. The variation is found to be 20-30% less for model having Composite Structure.

2. For Natural Frequency

The natural frequency of a structure is the rate of the exchange of kinetic and potential energy within the structure. The kinetic energy is associated with motion of structural mass, and the potential energy is stored by strains during deformation.

Table 2 Natural Frequency Comparison

Natural Frequency		
Mode	RCC	Composite
1	0.824	1.39
2	1.507	1.643
3	1.522	1.684
4	2.62	4.272
5	2.721	4.994
6	2.745	5.135

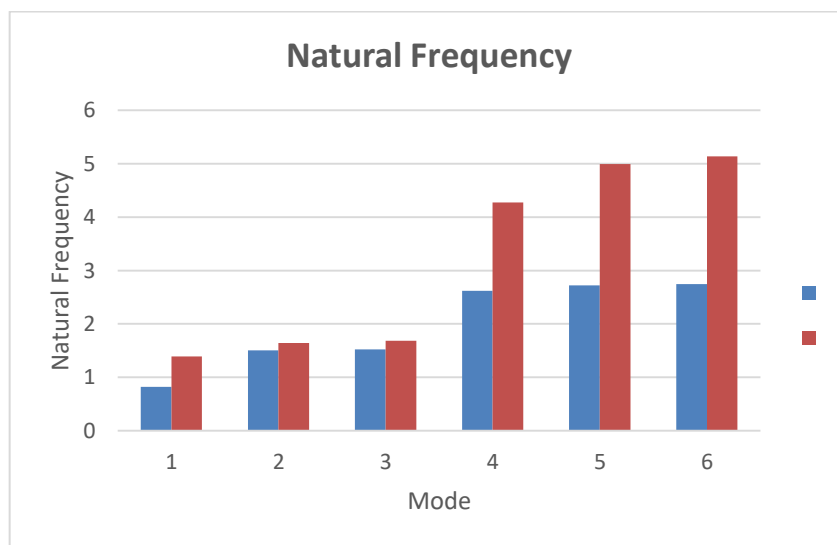


Fig 2. Natural Frequency Graph

From the above table & graph, observe that percentage variation for dynamic analysis, Natural Frequency for model 2 is high than model 1. The variation is found to be 30-40% high for model having Composite Structure.

3 Lateral Load to Stories

3.1 For X Direction

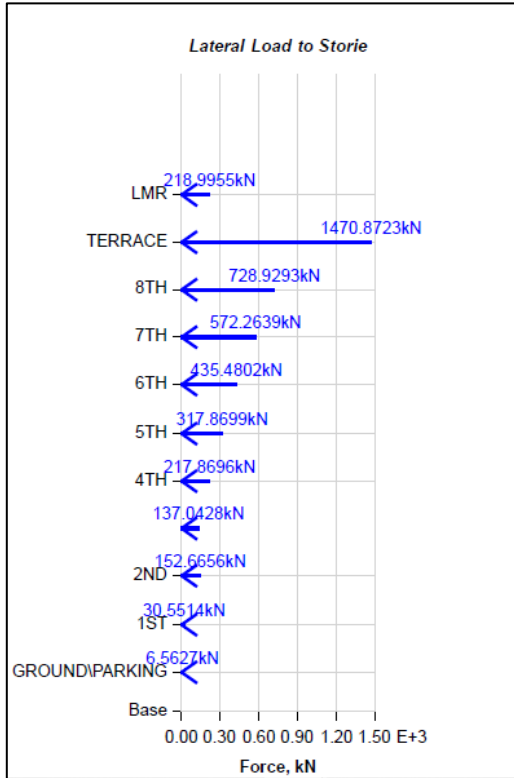


Fig 3. Lateral Load X Direction Model 1

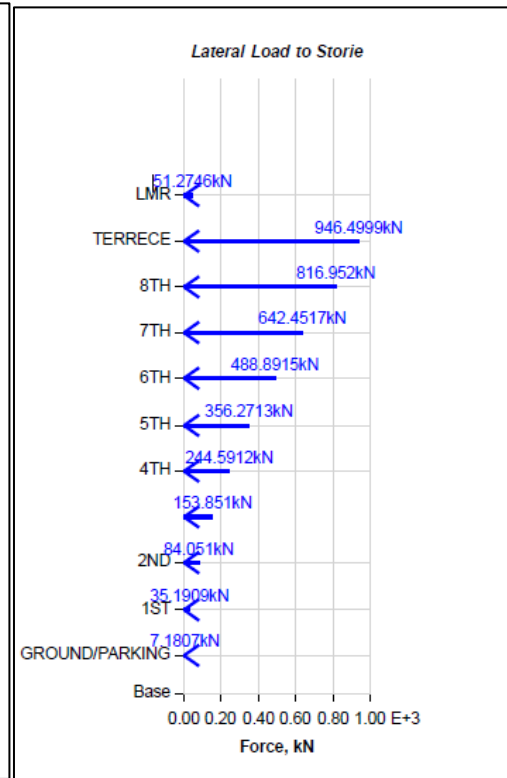


Fig 4. Lateral Load X Direction Model 2

Table 3. Lateral Load X Direction

Storey	Lateral Load X Direction	
	RCC	COMPOSITE
LMR	218.99	51.27
Terrace	1470.872	946.4999
8th	728.9293	816.952
7th	572.2639	642.4517
6th	435.4802	488.8915
5th	317.8699	356.2713
4th	217.8696	244.5912
3rd	152.6656	153.851
2nd	137.0428	84.051
1st	30.5514	35.1909
Ground	6.5627	7.1807

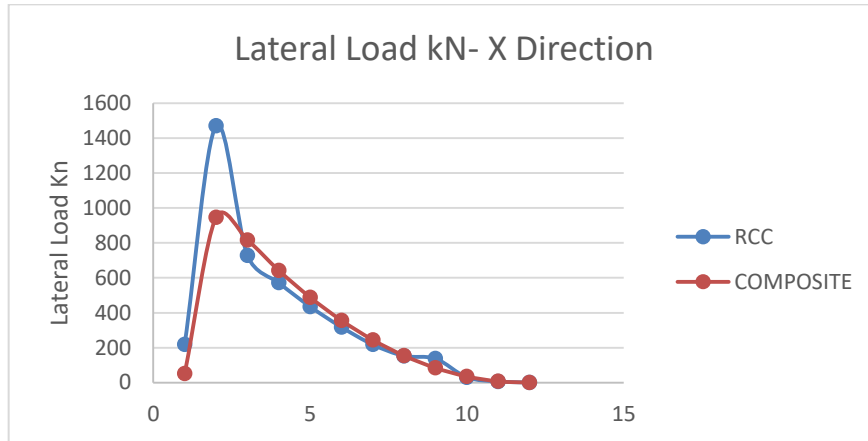


Fig 5. Lateral Load X Direction Graphical Comparison

From the above table & graph, observe that percentage variation for dynamic analysis, Lateral Load in kN for X Direction to model 2 is less than model 1. The variation is found to be 25-30% less for model having Composite Structure.

3.2 For Y Direction

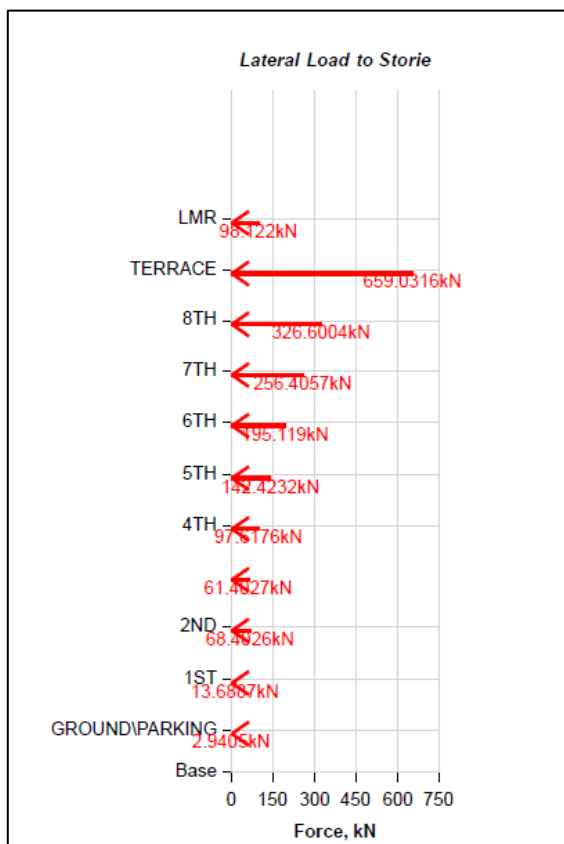


Fig 6. Lateral Load Y Direction Model 1

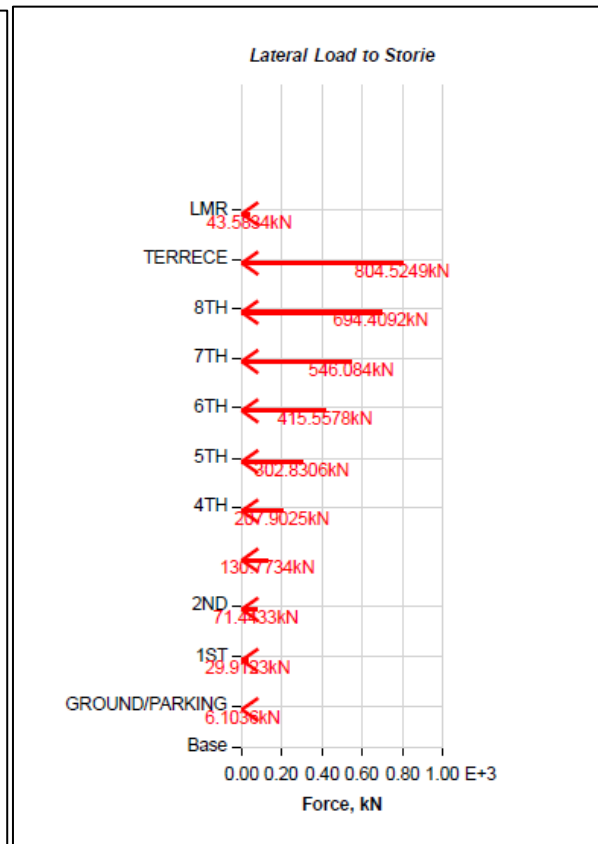


Fig 7. Lateral Load Y Direction Model 2

Table 4. Lateral Load Y Direction

Lateral Load Y Direction		
Storey	RCC	COMPOSITE
LMR	98.122	43.5834
Terrace	659.0316	804.5249
8th	326.6004	694.4092
7th	256.4057	546.084
6th	195.119	415.5578
5th	142.4232	302.8306
4th	97.6176	207.9025
3rd	68.4026	130.7734
2nd	61.4027	71.4433
1st	13.6887	29.9123
Ground	2.9405	6.1036
Base	0	0

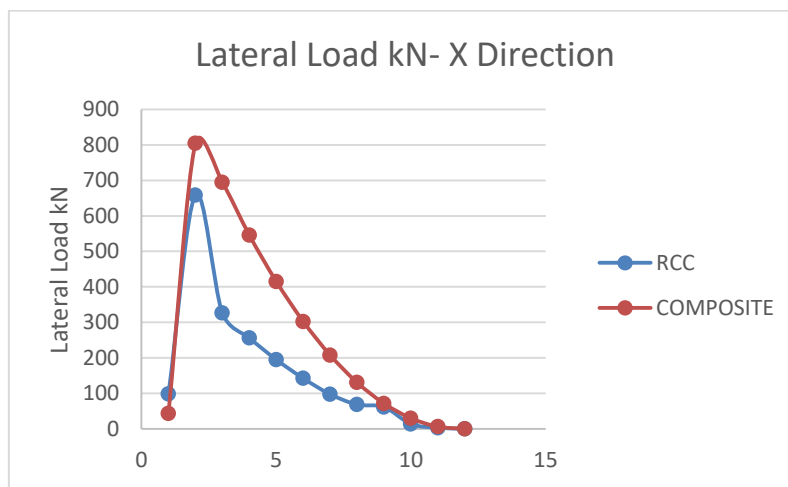


Fig 8. Lateral Load Y Direction Graphical Comparison

From the above table & graph, observe that percentage variation for dynamic analysis, Lateral Load in kN for Y Direction to model 2 is higher than model 1. The variation is found to be 30-35% high for model having Composite Structure. The variation of the results in composite structure for y direction is due to the direction of the composite deck.

IV. CONCLUSION

The conclusions of the study are given below:

- Percentage variation for dynamic analysis time period for model 2 is less than model 1. The variation is found to be 20-30% less for model having composite structure.
- Percentage variation for dynamic analysis, natural frequency for model 2 is high than model 1. The variation is found to be 30-40% high for model having composite structure
- Percentage variation for dynamic analysis, lateral load in kN for x direction to model 2 is less than model 1. The variation is found to be 25-30% less for model having composite structure.
- Percentage variation for dynamic analysis, lateral load in kN for y direction to model 2 is higher than model 1. The variation is found to be 30-35% high for model having composite structure. The variation of the results in composite structure for y direction is due to the direction of the composite deck.

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