

An Experimental Study on Use of Samanea Saman (Monkey Pod) With Bitumen as Additive

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ABSTRACT: The development of any economy anywhere in the world needs sophisticated infrastructures that are Roads, Airports and Runways& Parking lots. India, huge investments are being made to expand the existing road infrastructure and also to develop new highways for better connectivity as well as to serve the economic activity in the country. The demand of bitumen has exceeded the bitumen production & supply. The aging of bitumen binders is one of the key factors determining the lifetime of an asphalt pavement. There are different ways to improve asphalt mixture properties. First step is to construct road pavement with higher thickness & second is using different types of additives might be a better solution to overcome the pavement deterioration problem.

KEYWORDS: Bitumen, Samanea Saman, Marshall Stability Introduction.

I. INTRODUCTION

India is having 98% flexible pavement which is an important asset. They are always prone to various distresses during its service life caused by loading and weather-induced stresses. This project utilizes the naturally available monkey pod fruit, which has natural sticky property as additive in flexible pavement in order to reduce the use of chemical additive and in turn reduces the additional cost of additive. Hence, this research work has completed the Marshall Characteristics and specific gravity of asphalt mixture containing Samanea saman. Additionally, various properties of bitumen were assessed with addition of Samanea saman.

II. OBJECTIVES

The main objective of this research is use of Samanea saman (Monkey pod) as additive in flexible pavement construction and to check the stability using Marshall Method of bituminous mix design.

The Specific objectives of this study are as follows:

- ✓ To assess the effect of Samanea saman on the properties of bitumen as a partial replacement of bitumen.
- ✓ To determine the optimum percentage of Samanea saman in the bitumen mix.
- ✓ To study the strength of bitumen mix containing Samanea saman.

III. MATERIALS & METHODOLOGY

1. General

The present study deals with the strength characteristics of bitumen mix using Samanea saman as additive. In this study, an attempt is being made to check the feasibility of using the Samanea saman as partial replacement to bitumen and check the strength characteristics.

2. Collection and Preparation of powdered Samanea saman

The dry fruit was collected from various parts of Hassan. Then crushed using a wooden mallet and then the seeds were segregated from the pulp. The pulp of the fruit was grinded and then sieved through 2.36mm size sieve. The Samanea saman powder passing through 2.36mm sieve was considered for use in the research work.

3. Materials

The materials used and methodology adopted in this research work is as per “The Indian Standard Specification” and “American Society for Testing Materials”. The materials used are listed below,

Aggregates: 25mm down size, 12.5mm down size and 4.75mm down size

Bitumen: 30/40 grade

Samanea saman

4. Test for aggregates

The Physical characteristics of the aggregates were found out using “Indian Standard Specifications”.

5. Test for bitumen

The grade and other properties were found using “Indian Standard Specifications” and “American Society for Testing Materials”.

6. Marshall Stability test

The Marshall Stability and flow test provides the performance prediction measure for the Marshall Mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8mm/minute. Load is applied to the specimen till failure, and the maximum load is designated as stability. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.

Approximately 1200gm of aggregates and filler is heated to a temperature of 175-190⁰C. Bitumen is heated to a temperature of 121-125⁰C with the first trial percentage of bitumen (say 3.5 or 4% by weight of the mineral aggregates). The heated aggregates and bitumen are thoroughly mixed at a temperature of 154-160⁰C. The mix is placed in a preheated mould and compacted by a rammer with 75 blows on either side at temperature of 138⁰C-149⁰C. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. Vary the bitumen content in the next trial by +0.5% and repeat the above procedure. Number of trials is predetermined. The prepared mould is loaded in the Marshall Test setup.



Samanea saman fruit



Powdered Samanea saman



Conventional bitumen sample



Marshall Stability sample with Samanea saman fruit

IV. RESULT AND DISCUSSIONS

The analysis done and the results obtained in this research work are discussed in this chapter.

1. Tests on Coarse Aggregates

The test results obtained on the characteristics of coarse aggregates i.e., the specific gravity of the coarse aggregates obtained was 2.65. Water absorption was 0.26%. The abrasion value, crushing value and impact value were found to be 20.4%, 22.7%, 28.0% respectively. All the values lie well within the standard value.

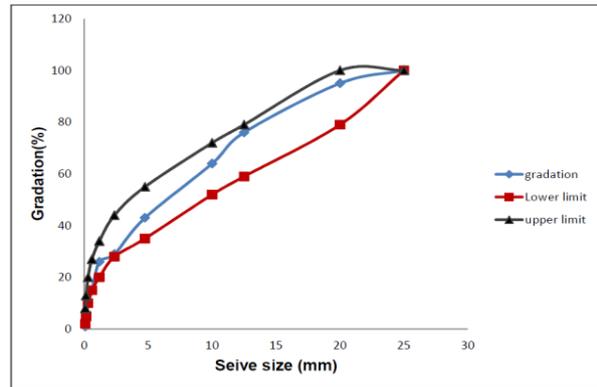


1.1 Gradation of coarse aggregates

The gradation of aggregates was done based on Job – mix formula. Mathematical procedures are available to determine an optimum combination of aggregates, but “Trial and Error Method” guided by a certain amount of reasoning is the most practical procedure to determine a satisfactory combination.

The gradation values are shown in the Table. The gradation of aggregates is necessary in order to obtain dense mix and to minimize the voids. The obtained gradation value lies within the MORT&H limits and the same is shown in the below figure.

Sl. No.	Sieve size (mm)	% passing materials			Obtained gradation 25:30:45	MOT&H Limits
		A(25mm)	B(12.5mm)	C(475mm)		
1	25	100	100	100	100	100
2	20	78.1	100	100	95	79-100
3	12.5	9.9	96.6	100	76	59-79
4	10	2.1	61.4	100	64	52-72
5	4.75	0.2	8.7	89.79	43	35-55
6	2.36	0	0	63.42	29	28-44
7	1.18	-	-	57.6	26	20-34
8	0.6	-	-	32.78	15	15-27
9	0.3	-	-	22.33	10	10-20
10	0.15	-	-	9.26	4	5-13
11	0.075	-	-	1.9	1	2-8



2. Tests on Bitumen

The test results obtained on the characteristics of a bitumen. The penetration value obtained was 35.5mm, from the penetration value the bitumen can be classified as 30/40 grade.

The ductility value obtained was 73cm, the specific gravity was found to be 1.05, the softening point was found to be 64.3⁰C, the viscosity value obtained was 158sec and the flash point was 183⁰C.

3. Tests on Samanea saman

The properties of Samanea saman were obtained from WoodDatabase.com i.e., the specific gravity of Samanea saman is 0.60. The Modulus of rupture and crushing strength were 65.7 N/mm² and 39.9N/mm² respectively.

4. Tests on Bitumen blended with Samanea saman

The test results of bitumen blended with Samanea saman in varying percentage of 1%, 2%, 3%, 4%, 5% and 6% as partial replacement to bitumen.

4.1 Ductility test

Ductility is an important characteristic of bitumen. Since road bitumen should be elastic to overcome the surface movements, this test shows in a certain degree, the elasticity of the material. This test gives a measure of adhesive property of bitumen and its ability to stretch.

The ductility value is decreasing as the percentage of Samanea saman is increased but lies within the minimum ductility value for 30/40 grade i.e.10cm.

4.2 Viscosity test

Viscosity test is used to control the consistency which in turn to determines the grade of bitumen. Viscosity is more scientific parameter to measure consistency. Consistency/viscosity is resistance of a material to flow. The viscosity affects the ability of the binder to spread, move into and fill up the voids between aggregates. It plays important role in coating of aggregates.

The binders are classified into viscosity ranges according to the time (seconds), required for a given amount of binder to flow through specified orifice at the bottom of the container. The viscosity value increases with the increase in percentage of Samanea saman.

4.3 Softening test

The softening point of bitumen is the temperature at which the substance attains a particular degree of softening. Different grades of bitumen soften at different temperature. The bitumen does not have a definite melting point, but instead the transition from solid to liquid is slow and gradual. Determination of softening point helps to know



the temperature up to which a bituminous binder should be heated to have sufficient fluidity for applications in road use. This test is also called ‘Ring and Ball Test’.

The softening point also increases with increase in percentage of Samanea saman added.

4.4 Penetration test

It is a consistency test, which determines the hardness or softness of bitumen. This test is used for classification of bitumen grade and for evaluation consistency of bituminous materials. The lower the value of penetration, the harder is the bitumen.

From the penetration value shown in below table, it can be concluded that the bitumen grade is 30/40 grade bitumen. The penetration value decreases with the increase in percentage of Samanea saman added.

Sl. No.	Samanea Saman added (%)	Ductility (cm)	Viscosity (sec)	Softening Point (°C)	Penetration (mm)
1	0	73.0	158	64.3	35.5
2	1	61.6	185	66.2	32.6
3	2	49.4	298	70.1	30.2
4	3	39.5	310	77.8	29.1
5	4	30.8	365	80.0	27.6
6	5	27.5	414	82.5	26.3
7	6	25.4	465	85.4	25.2

5. Marshall Stability Test

5.1 Theoretical specific gravity of the mix G_t

Theoretical specific gravity G_t is the specific gravity without considering air voids, and is given by,

$$G_t = \frac{W_1+W_2+W_3+W_b}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_b}{G_b}} \dots\dots\dots(1)$$

Where,

- W_1 - weight of coarse aggregate in the total mix.
- W_2 - weight of fine aggregate in the total mix.
- W_3 - weight of filler in the total mix.
- W_b - weight of bitumen in the total mix.
- G_1 - apparent specific gravity of coarse aggregate.
- G_2 - apparent specific gravity of fine aggregate.
- G_3 - apparent specific gravity of filler and
- G_b - apparent specific gravity of bitumen.

5.2 Bulk specific gravity of mix G_m

The bulk specific gravity or the actual specific gravity of the mix G_m is the specific gravity considering air voids and is found out by,

$$G_m = \frac{W_m}{W_m - W_w} \dots\dots\dots(2)$$

Where,

- W_m - Weight of mix in air.
- W_w - Weight of mix in water.
- $(W_m - W_w)$ - Volume of the mix.

5.3 Air voids percent V_v

Air voids V_v is the percent of air voids by volume in the specimen and is given by,

$$V_v = \frac{(G_t - G_m) * 100}{G_t} \dots\dots\dots(3)$$

Where,

G_t - theoretical specific gravity of the mix given by equation (1) and



G_m - bulk or actual specific gravity of the mix given by equation (2).

5.4 Percent volume of bitumen V_b

The volume of bitumen V_b is the percent of volume of bitumen to the total volume and given by,

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_4}{G_m}} \dots\dots(4)$$

Where,

- W_1 - Weight of coarse aggregate in the total mix.
- W_2 - Weight of fine aggregate in the total mix.
- W_3 - Weight of filler in the total mix.
- W_b - Weight of bitumen in the total mix.
- G_b - Apparent specific gravity of bitumen and
- G_m - Bulk specific gravity of mix given by equation (2).

5.5 Voids in mineral aggregate VMA

Voids in mineral aggregate VMA is the volume of voids in the aggregates, and is the sum of air voids and volume of bitumen, and is calculated from

$$VMA = V_v + V_b \dots\dots\dots(5)$$

Where,

- V_v - Percent air voids in the mix given by equation (3) and
- V_b - Percent bitumen content in the mix given by equation (4)

5.6 Voids filled with bitumen VFB

Voids filled with bitumen VFB is the voids in the mineral aggregate frame work filled with the bitumen and is calculated as,

$$VFB = \frac{V_b * 100}{VMA} \dots\dots\dots(6)$$

Where,

- V_b - percent bitumen content in the mix given by equation (4) and
- VMA - percent voids in the mineral aggregate, given by equation (5).

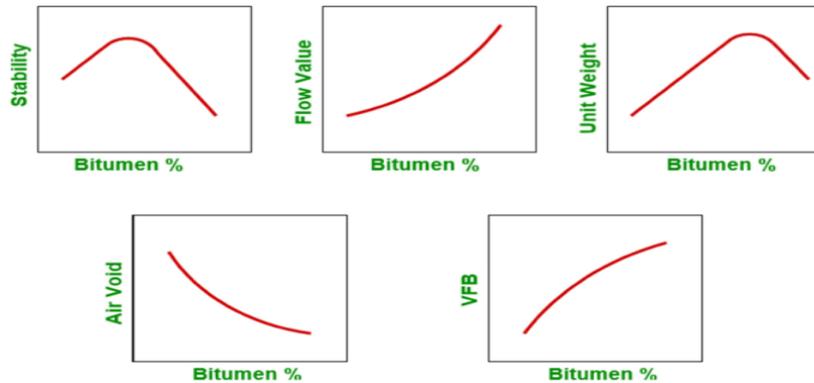
5.7 Determine Marshall Stability and flow

Marshall Stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain (5 cm per minute). While the stability test is in progress dial gauge is used to measure the vertical deformation of the specimen. The deformation at the failure point expressed in units of 0.25 mm is called the Marshall Flow value of the specimen.

5.8 Prepare graphical plots

The average values of the above properties are determined for each mix with different bitumen content and the following graphical plots are prepared,

1. Bitumen content versus corrected Marshall Stability (KN).
2. Bitumen content versus Marshall Flow (mm).
3. Bitumen content versus percentage of void (V_v) in the total mix.
4. Bitumen content versus voids filled with bitumen (VFB).
5. Bitumen content versus unit weight or bulk specific gravity (Gm).



Marshall graphical plots

5.9 Marshall Stability test to find optimum bitumen content

The Marshall Stability test results obtained to find the optimum bitumen content are as shown in the below table. The properties that are of interest include the theoretical specific gravity G_t , the bulk specific gravity of the mix G_m , percent airvoids V_v , percent volume of bitumen V_b , percent void in mixed aggregate VMA and percent voids filled with bitumen VFB.

The graph of percentage bitumen content versus Marshall Stability value (KN) is as shown in the below figure. The stability value of the mix increases with increasing bitumen content until a maximum value is obtained, after which the stability decreases. At maximum stability test internal friction, interlocking of aggregates and cohesion is provided. The maximum stability value obtained is 34.6 KN for 6% bitumen content. Hence 6% of bitumen is taken as the optimum bitumen content.

The graph of percentage bitumen content versus Marshall Flow value (mm) is as shown in the below figure. The flow value increases as bitumen content increases, the rate of deformation change is slow at low bitumen contents, but increases rapidly at higher bitumen content. Surfacing with low flows and high stability will not deform easily under traffic. The flow is increasing with the increase in bitumen percentage. The percentage of voids in the total mix decreases with increase in bitumen content until a value is reached at which it begins to level off. When air void content is too low the surfacing may bleed under traffic.

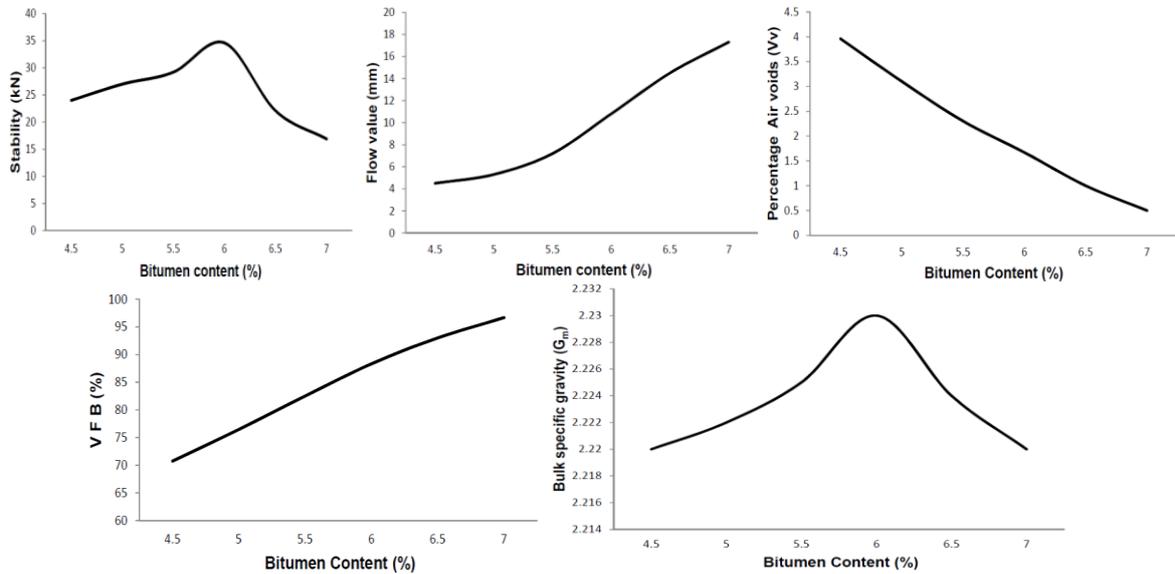
The graph of percentage bitumen content versus percentage air voids is as shown in the below figure. The percentage air voids is decreasing with the increase in bitumen content. The percentage of aggregate voids filled with bitumen increases with increasing bitumen content, until a maximum value is reached. Rate of increase is fastest at low bitumen content and levels off at high content. When surfacing is deficient in bitumen content, it may become brittle and crack early and ravel under traffic.

The graph of percentage bitumen content versus percentage voids filled with bitumen (V F B) is as shown in the below figure. The percentage of voids filled with bitumen is increasing with the increase in bitumen content.

The graph of percentage bitumen content versus bulk specific gravity (G_m) is as shown in the below figure. The unit weight of mix increases with increasing bitumen content until a maximum value is obtained, after which unit weight decreases. At first, bitumen acts as a lubricant and helps the aggregate particles to slide over each other. After optimum, it starts displacing the particles. For dense mixes therefore it is important that amount of binder should not exceed the optimum for the compaction used. The maximum bulk specific gravity value obtained is 2.23 for 6% bitumen content. Hence 6% of bitumen is taken as the optimum bitumen content.

Sl. No.	Bitumen Content (%)	Stability (KN)	Flow (mm)	% air voids (v_v)	V_b	VM A	VFB	G_t	G_m
1	4.5	24.0	4.5	3.96	9.57	13.53	70.74	2.31	2.22
2	5.0	27.0	5.3	3.10	10.59	13.85	76.47	2.30	2.22
3	5.5	29.2	7.2	2.30	11.60	14.26	82.5	2.29	2.22
4	6.0	34.6	10.8	1.67	12.64	14.31	88.33	2.27	2.23
5	6.5	22.1	14.5	1.00	13.68	15.06	93.00	2.26	2.22
6	7.0	16.9	17.3	0.50	14.61	15.11	96.68	2.24	2.22

Marshall Stability test values to find optimum bitumen content



Marshall Graphical Plots

5.10 Marshall Stability test to find optimum Samanea saman content

The Marshall Stability test results obtained to find the optimum Samanea saman content are as shown in the below table. The properties that are of interest include the theoretical specific gravity G_t , the bulk specific gravity of the mix G_m , percent air voids V_v , percent volume of bitumen V_b , percent void in mixed aggregate VMA and percent voids filled with bitumen VFB.

The graph of percentage of Samanea saman versus Marshall Stability value (KN) is as shown in the below figure. The Marshall Stability value of the sample replaced with 1%, 2% and 3% of Samanea saman is 43.8KN, 39.0KN and 36.6KN respectively, whereas the Marshall stability value of the conventional bitumen sample is 34.6KN.

The graph of percentage of Samanea saman versus Marshall Flow value (mm) is as shown in the below table. The flow is increasing with the increase in Samanea saman percentage.

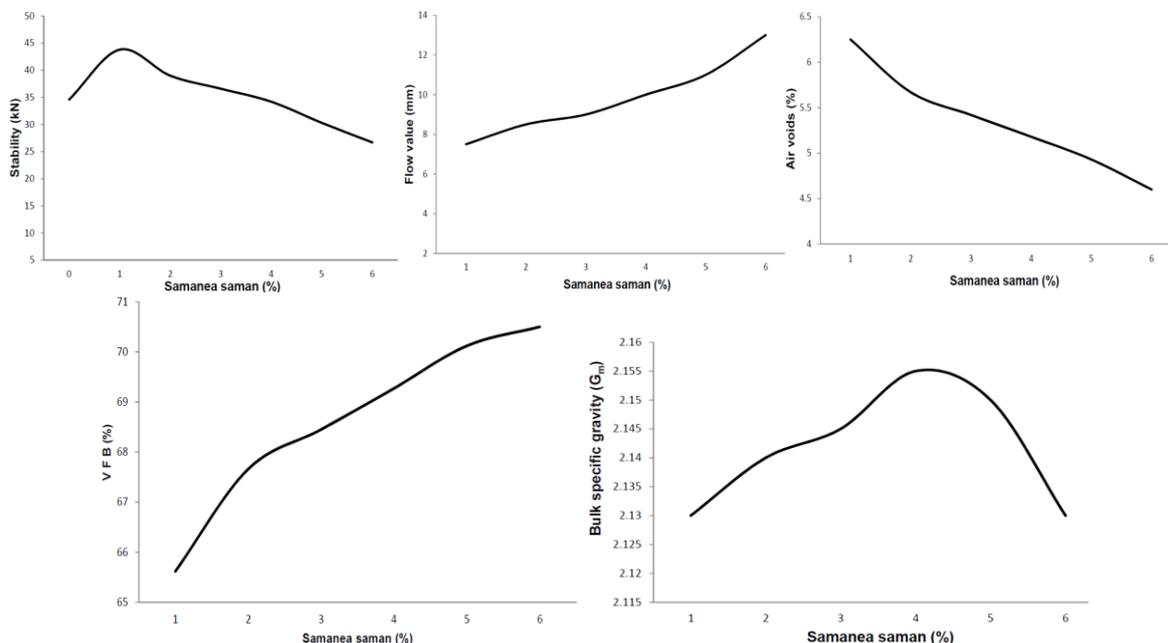
The graph of percentage of Samanea saman versus percentage air voids is as shown in the below figure. The percentage air voids is decreasing with the increase in Samanea saman content.

The graph of percentage of Samanea saman versus percentage voids filled with bitumen (VFB) is as shown in the below figure. The percentage of voids filled with bitumen is increasing with the increase in Samanea saman content.

The graph of percentage of Samanea saman content versus bulk specific gravity (G_m) is as shown in the below figure. The maximum bulk specific gravity value obtained is 2.155 for 4% Samanea saman content but the strength slightly reduces than the conventional bitumen.

Samanea Saman (%)	Stability (KN)	Flow (mm)	% Air voids (V_v)	V_b	VMA	VFB	G_t	G_m
0	34.6	10.8	1.67	12.64	14.31	88.33	2.27	2.23
1	43.8	7.5	6.25	11.92	18.17	65.62	2.27	2.13
2	39.0	8.5	5.67	11.87	17.54	67.66	2.27	2.14
3	36.6	9.0	5.42	11.77	17.19	68.45	2.27	2.145
4	34.2	10.0	5.18	11.66	16.84	69.27	2.26	2.155
5	30.3	11.0	4.93	11.56	16.49	70.12	2.26	2.15
6	26.7	13.0	4.6	11.48	15.99	70.50	2.26	2.13

Marshall Stability test values to find optimum Samanea saman content



Marshall Graphical Plots

VI. CONCLUSIONS

Based on the literature citation, experiments conducted and results obtained the following conclusions may be drawn.

- ✓ The Marshall stability of the sample replaced with 1%, 2% and 3% of Samanea saman is 43.8kN, 39.0kN and 36.6kN respectively, whereas the Marshall stability of the conventional bitumen sample is 34.6kN.
- ✓ The optimum percentage of bitumen is found to be 6%.
- ✓ The Marshall Stability value of 1% replacement of Samanea Saman for bitumen has increased by 27%.
- ✓ The Marshall Stability value of 2% replacement of Samanea Saman for bitumen has increased by 13%.
- ✓ The Marshall Stability value of 3% replacement of Samanea Saman for bitumen has increased by 6%.
- ✓ The Marshall Stability value of 4% replacement of Samanea saman for bitumen has decreased by 1.16 % but it has the maximum bulk specific gravity of 2.155.
- ✓ From all the results obtained we can replace Samanea saman up to 4% as a replacement for bitumen.

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