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IMPACT ASSESSMENT OF MECHANICAL SERVICES TO BUILDING INSTABILITY

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A B S T R A C T

Building industry is a core aspect in any nation's economy growth. Buildings tend to fail depending on several factors and level of stockholders' involvement. This study examined whether or not mechanical elements have association with the prevalent of building collapse in the study area. Questionnaire was used to collect data in some construction sites in Lagos, Nigeria which included construction professionals, supervisor, architects, structural engineer, quantities surveyors, mechanical and electrical engineers. Chi-square, cross tabulation and correlation were used to analyse the primary data on SPSS. About 80% of the respondents reported to have had experiences of building collapse, 89% attached high importance to inclusion of all relevant experts (mechanical services (MSs) inclusive) for optimum building strength and sustainability. The key areas of MSs reported requiring experts attention include; prevention of spillages from pipe leakages (72%), conduct piping (60%), drainage piping (57%) and soak-away-pit location (55%). Chi-Square =39.139, df =2 and p =0.001, indicated that the participants' years of experience influenced. More than 50% who had spent above 4years on the job affirmed that proper MSs could help reduce the count of building collapse. It was affirmed that relevance of mechanical experts cannot be underrated if building strength must be sustained.

1. INTRODUCTION

These Building failure leads to building collapse. Building collapse is as a result of the total failure of the building elements and components (Ikpo, 2006). Failure occurs in building when it loses ability to perform its intended function and this can be categorized into either physical (structural) failures or performance failures (Douglas and Ransom, 2007). Folagbade (2001) and Chinwokwu (2000) reported cases of building collapse in Nigeria as very alarming. They enumerated forty-two (42) cases of building collapse that occurred between 1980 and 1999, fifty-four (54) cases between 2000 and 2007. According to Building Collapse Prevention Guild (BCPG) (2020), in 2019 alone there were more than 40 reported building collapse incidents in Nigeria and it was previously warned by BCPG that 36,000 building

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collapses were waiting to happen in Lagos alone. Makinde (2007), however, emphasized on the increasing counts of building collapse as needing urgent attention as it had claimed several lives and properties in the recent years especially in Lagos, the commercial nerve centre of Nigeria (Olayinka, 2017).

Building failure may increase when any of the three professional parties involved in building construction trade - consultants, contractor and developer/ owner are not fully engaged and/or when incompetent personnel are in charge (Bolaji, 2002) leading to poor design and use of low quality materials (Chendo and Obi, 2015).

Cracks in a building may be among the early signs of impending building collapse. A building component develops cracks whenever building component are unnecessarily bombarded with stress such as (Rama, et al., 2015) unprofessional cutting of walls and structures (usually carried out by unskillful workers). As reported by Oke, (2011), poorly skilled workmen stand one of the main reasons behind the incidents of increasing building collapse. Poor skill makes it difficult or impossible for workers to apply the concepts of quality control as many of them are difficult to instruct on site (Obi, 2015). Engagement of inexperienced personnel to take charge of any part of construction works will lead to covering up of shoddy or defective works (Olusola, 2002). Hence the need for professionals such as the Architects and relevant Engineers, to be fully included in building construction works.

The Architects carry out designs of buildings which usually include pictorial sketches and/or mode and responsible for overall supervision of the project. Engineers such as structural, electrical, mechanical carry out various designs which are relevant to their specialist fields. During project execution stage, engineers visit the site for supervisions to ensure the work being carried out is in compliance with the design and specifications. While the structural engineering is more concerned with the design and the physical integrity of the structures, Electrical engineering sees to all electrical components of the building and equipment. Mechanical engineering field covers the design of HVAC equipment, the ducts and ventilation shafts. During the construction, a mechanical engineer supervises all installations of mechanical components such as pipes (drainage, water, fire, gas) which are common task in plumbing, the air conditioning systems of buildings among others. It is therefore the duty of mechanical engineer on site to ensure quality of all pipe installations and prevent leakages.

This study assessed into the impact(s) of mechanical elements' inclusion in the built industry vis-à-vis building instability. The objectives are to examine whether or not mechanical elements in building have significant association with building collapse and possibly identify some of the mechanical inputs that require adequate attention of mechanical experts

2. MATERIAL AND METHODS

2.1 The study area

The study involved 120 professional in the building construction industry which included structural engineer, quantity surveyor, builder, mechanical engineers, electrical engineers, and architects. Nineteen (19) construction sites were selected from Lagos State. Lagos state is located on the south-western part of Nigeria and lies approximately between longitude 2o 42'E and 3o 22'E and between latitude 6o 22'N and 6o 42' N. Lagos State encompasses an area of 358,862 hectares or 3,577 sq.km which is about 0.4 percent of the total land area of Nigeria (https://lagosstate.gov.ng/about-lagos). The study sites were those involving construction of new building, and renovation works. The target groups of participants were assessable through writing and oral interviews. Permission was given by the management of each site after letters were written ahead by the researchers stating the purpose of visit to the sites. This was to secure approved date of interview from the site managers and for adequate preparation needed for the interview.

2.2 Preparation for the study sites

Constructive advice was obtained before the commencement of the research and the ethical approval to carry out the research, which contained a set of instructions on how to ensure safety (for both researchers and the participants) during the course of the study, was received from the ethical committee in the work domain of the researchers.

2.3 Study subjects

A qualitative analysis descriptive statistics study was used in the study to select 112 participants which include professionals like architects, structural engineer, quantities surveyors, mechanical, electrical engineers and other supervisors. These participants were grouped into 3, those in the managerial positions, supervisory position and the skilled workers who had spent at least 3 years on building construction job. The management of various sites identified for the study was written by the researchers. The purpose of the study and the confidentiality of the information contained in the questionnaire were emphasized. Consents of all site managers and the date of interview were received in writing. It was noted that the majority of the study populations had been briefed ahead by their managers. Notwithstanding, the reasons for the study were fully communicated to all the participants so that they can voluntarily decide their participation. Study populations were also informed that their participation

in the study was voluntary. Consents were however obtained in oral form from all potential participants.

2.4 Personal data collection, job demand and work station assessment

Personal protective equipment provided by the site managers were used before gaining access to the sites. These included helmet, safety shoes, goggle and apron.
Personal data were collected from participants using a well-structured questionnaire for parameters such as participants' demographic information, information related to prevalence of witnessed building collapse during and after construction activities, subjective opinions on the importance attached to experts' involvement in building construction works among others. The questions were structured in English language because almost all the participants could read and communicate in English language. The questions were simple and they were well explained during the interview.
Data collection covered a period of twelve months, from May 2020 and ended on April 2021. The data collection spanned for a year because some managers could not be accessed easily and the researchers needed to wait until their consents for the interview were received. Not less than one week was, however, spent in each of the study sites.

2.5 Data analysis

The data collected was analysed using Statistical Package for the Social Sciences (SPSS).. The study tested some hypothesis by conducting correlation and Chi-Square statistics. These include the determination of whether to accept or reject the null hypothesis statements that:

i.. There is no correlation between the opinions of the study populations regarding the contribution of mechanical services to building collapse.
ii. There is no influence of working experience on study population responses
iii. There is no significant relationship between the respondents' job status and their opinions on the influence of mechanical services on building collapse.

3. RESULTS

3.1 Demographic information

One hundred and fifty (150) questionnaires were distributed through oral and written interview out of which one hundred and twenty (120) representing 80% were recovery.

As shown in Table 1, about 48% of the total study population were managers, 36% were supervisors and 16% were skilled workers. In all the categories, those who have spent above 10 years in the industry were 44%. About 50% had spent between 4 to 10 years while 54% of the study population had one to three years of working experience in the building industry. About 49% of the total study populations were degree holders, 45% of them had completed their post graduate studies and 6% had no former education.

3.2 Prevalent of Building collapse among the study population

Figure 1 shows the outcome of responses of the study populations on whether or not they had witnessed building collapse either in part or total during or after building construction projects.

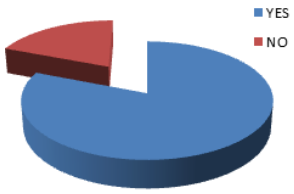


Figure 1. Reported prevalent of building collapse among the study population

From the figure, 81% of the total respondents reported to have witnessed incidences of building collapse. Out of this group, 28% reported partial collapse of some portion during renovations of existing building and the majority (72%) had witnessed collapse of other buildings at some times but that the incident occurred after the buildings were commissioned. However none of the respondents associated the collapse of the affected building to laspses emanated from them of their establishment.

Table 1. Demography information of the study population

Description	Status in the construction work (%)	Working Experience (%)	Educational Background (%)
Skilled worker	16		
Supervisor	36		
Manager	48		
Between 1-3 years		24	
Between 4 -10 years		51	
Above 10 years		25	
No former Education			6
Degree holder			49
Post-Graduate workers			45

Figure 2 shows the opinions of the study participants on the causal factors for building collapse. From the figure, 10% of the respondents ascribed building collapse to uncontrolled involvement of in-experts in the capacity of labourer or supervisors, 17% specifically stretched on poor job supervision as the major cause. However, 20% of the respondents associated the casal factors to poor design of building elements while 24% credited the incidence to the use of improper and/or fake building materials.

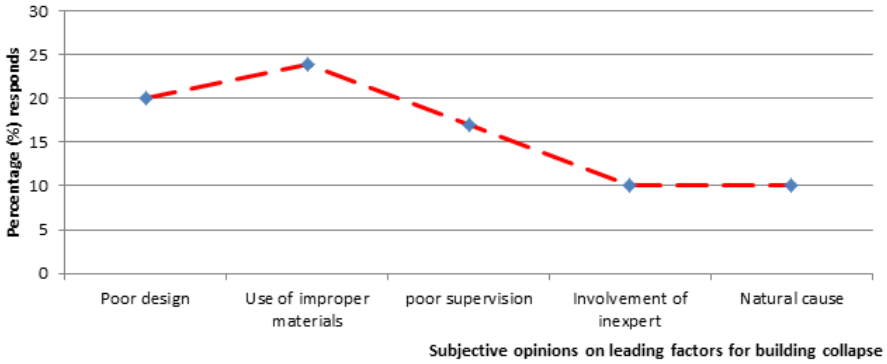


Figure 2. Reported causal factor for building collapse

3.3 Relevance of experts' involvement in building constrction works

As shown in Figure 3, majority of the study population (72%) ascribed "very important" rating to total compliant with Structural Engineers' detail design in construction works than the score allocated to Architectural designs (62%). However (30%) and (31%) respectively attributed "important" score to Electrical and Mechanical Engineers' detail lesser than score alloted to the Structural and Archtect drawing but higher in value to Quantity surveyors' (26%) contribution.

However, from Figure 4, majority of the respondents apportioned greater importance to Structural engineer's supervision than any cadre of professionals relevant in the industry.

Hence 82% of the respondents placed "very important" to the relevance of structural engineers' supervisions above that of Architect (52%), 45% and 36% scored the relevance of competent Mechanical and the Electrical engineers' contributions respective as "very important

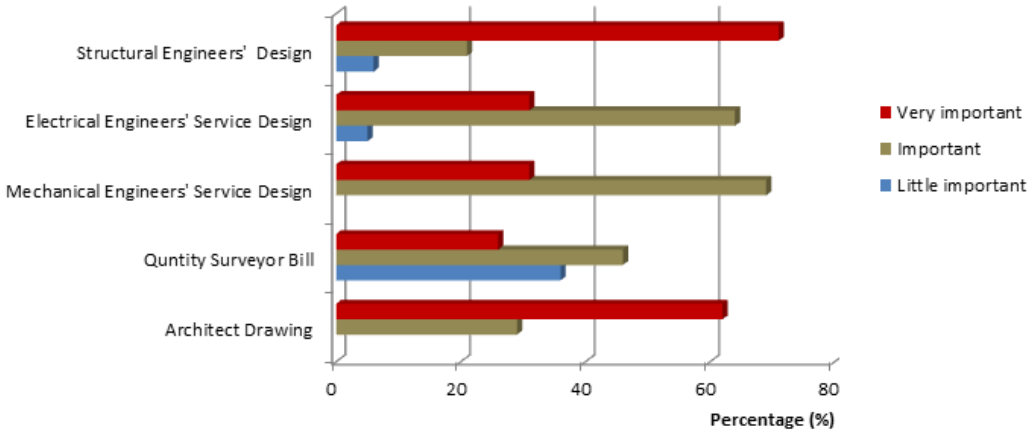


Figure 3. Opinions of the study population on relevance of professionals in building constrction works

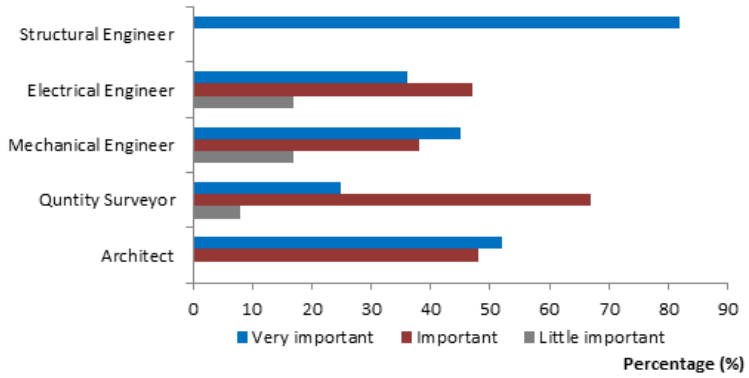


Figure 4. Ratings of the importance of different professionals in building construction

3.4 Ratings of proper design for mechanical services

Participants subjectively responded to the level of importance attached to supervision of project execution by qualified mechanical engineers. As it can be shown in Figure 3.5, 89% of the respondents attached a very high importance to ensuring that mechanical experts supervise mechanical services related jobs.

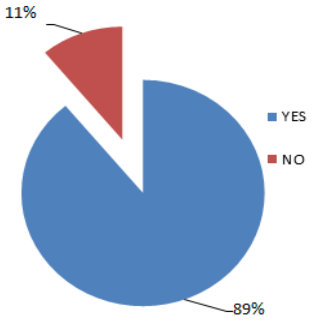


Figure 5. Responses on whether proper mechanical design and supervision can sustain building strength

3.4.1 Areas of importance for mechanical elements

To be specific, Figure 6 highlighted some of the areas where proper handling of mechanical input are very important, failure to which may contribute to weakness of building structure.

From the figure, more than 80% of the study population identified water piping design and supervision as having high tendency to cause building collapse and should be supervised by qualified mechanical engineer. Other areas widely reported as having potentials to cause instability in building structure include; spillages from pipe leakages (72%), poorly installed conduct piping (60%), drainage piping (57%) and location of soak-away-pit (55%).

As confirmed by the various professionals (Figure 7), most of the respondents strongly agreed that poor mechanical design had led to, and may continue to cause unprofessional cuttings of building structure element which may weaken the strength of the building.

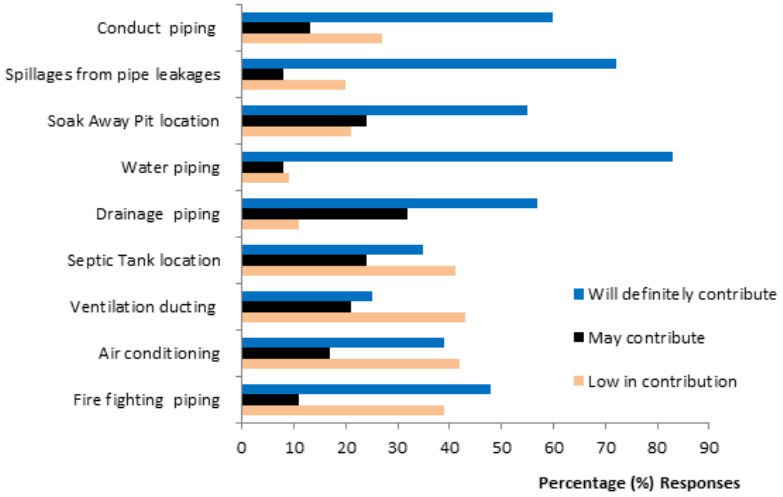
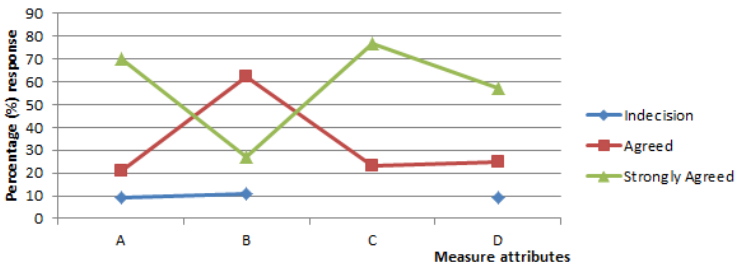


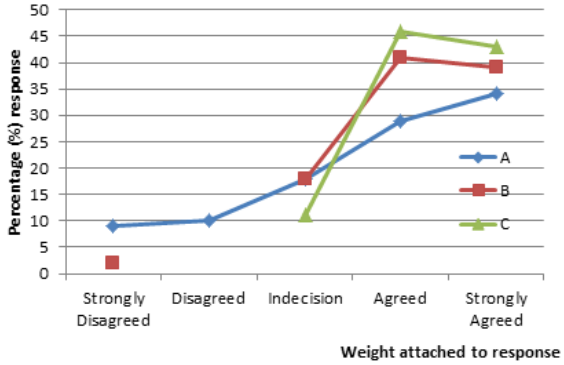
Figure 6. Emphasizes on mechanical services areas of concern for building collapse



A= Poor mechanical design lead to unprofessional breakings
B= Inexperienced Plumber contribute to weakness of building strength
C=Unnecessary breaking during installation of pipes can reduce the building strength?
D = All engineering design inputs help to sustain the strength and stability of a building?

Figure 7. Mechanical engineering services activities prone to building damages

The report as indicated in the figure shows that 62% of the respondents further revealed that inexperienced plumbers sometimes engaged to carry out mechanical installations was among the main contributors to building weakness. More than the average (57%) of the respondents strongly agreed that all engineering design, including mechanical services, can help to further sustain building stability.



A= Good design and installation of mechanical services is a parts of building strength

B = Poor handling of mechanical installations contribute to building collapse?

C = Involvement of inexpert to handle mechanical services in building projects lead to building failure?

Figure 8. Respondents' opinions on mechanical installation in relation to building collapse

3.5 Statistic tests

3.5.1 Test One: Contribution of mechanical services to building collapse (Hypothesis statement 1)

The Null Hypothesis: - There is no significant relationship between the years of working experience of the study populations and their responses to the relevance of Mechanical elements to building structure sustenance.

Table 2. Contribution of mechanical services to building collapse

S/N	Discription	Value	Sig. (2-tailed)	Remark
1	Drainage piping	.609	.001	Significant
2	Water piping	.744	.001	Significant
3	Firefighting piping	.247	.008	Significant
4	Air conditioning piping	.583	.001	Significant
5	Ventilation ducting	.139	.169	Significant
6	Septic Tank location	.247	.008	Significant
7	Soak Away Pit location	.641	.001	Significant
8	Spillages from pipe leakages	.822	.001	Significant
9	Conduct piping	.641	.001	Significant

On whether there is correlation or not between the opinions of the study populations regarding the contribution of mechanical services to building collapse, Table 2 shows a statistic test to ascertain the correlation between opinions of all the respondents on the role that some mechanical input could play in building collapse.

From the table the general opinion scale of all participants on how piping design can lead to building were all significant. In a similar trend, participants' agreements on how locations of Septic Tank and Soak-away pit could affect the focal problem are significant. The entire null hypotheses were rejected for the alternatives. This can be interpreted to mean that there existed a relationship between the respondents' opinions. However why all others were considered as moderate, the correlation strength of the effect of firefighting piping and Septic tank location on building collapse were considered very weak.

3.5.2 Test 2: Influence of working experience on study population responses

Chi-square test result (Chi-Square = 39.139, df =2 and p =0.001) about the influence of working experience on participants' responses to the relevance of mechanical services, rejected the null hypothesis II for the alternative. Hence, there existed a relationship between the two groups of variables tested and can be interpreted that the years of experience of the individual respondent affected their responses to whether mechanical services had anything to do with building stability or not.

The highest number of respondents (Table 3) was from those who had spent between 4 to 10 years on building project works. This was followed by those who had spent more than 10 years in the industry. However, those who have spent more than 3 years agreed that proper design of mechanical engineering elements could help prevent building collapse.

Table 3. Cross tabulation on the responses of the study population to theirworking experience

Experience	Can proper design of Mechanical Engineering services help prevent building collapse?	
	Yes (%)	No (%)
Between 1-3 years	13	11
Between 4 -10 years	51	0
Above 10 years	25	0
Total	89	11

3.5.3 Test 3: Contributions of Mechanical Service and the influence of work status on study population responses

Chi-square test result (Chi-Square = 0.01312, df =16 and p =0.001) on whether or not the job status of the respondents influenced their responses to the degree of influence attached to mechanical services in building construction, rejected the null hypothesis for the alternative. Hence there existed a relationship between the respondents' job status and the manner at which ratings were allocated to the perceived influence of mechanical elements on building strength. It can therefore be interpreted that each job cadre had divergent opinion about the contribution of mechanical elements to whether building structure will be stable or not.

3.6 Discussion

Assessment into the impact(s) of mechanical elements' inclusion in the built industry was the focus of this study. The study included three categories of workers; managers, supervisors and other workers. Majority of the study population had spent more than 3 years in the building industry and had at least a certificate of higher institutions of learning. Majority of the study participants had experiences of building collapse either as partial or total collapse of the entire structure. Those in the category of total collapse were aged buildings that were subjected to renovations works. However, none of the respondents took responsibility for the various degree of the reported building collapse.

On participants' suggested future prevention of building collapse, majority awarded the highest possible marks to the importance of the involvement of Structural Engineers' design and supervisions than any other professionals in the building industry. However some of them emphasised on the need for proper design of electrical and mechanical elements and expert's supervisions of its installations. They opined that the involvement of these experts at ensuring sucessful and sustanable building constructions can not be underrated. The aspects of mechanical services widely highlighted by the study population requiring adequate attention of experts so as to prevent weakening of building structure include; water piping, spillages from pipe leakage, conduct piping and location of soak-away-pit. Majority of the professionals who had spent many years in the industry strongly supported that poor mechanical design and supervision of mechanical installation had repeatedly led to unprofessional cutting of delicate parts of building structure. According to the National Fire Chiefs Council (2020), building may collapse when exposed to additional forces such as cutting structural elements. If the critical load-bearing walls are removed during the cutting operation, there will be a negative impact on the stability of the structure. It was also opined that the menance may continue to cause building collapse unless it is properly addressed.

Many of the participants agreed that the involvement of inexperienced plumber coupled with poor supervisions were the reasons for some of the shaddy mechanical services installation jobs carried out on construction sites. This unprofessionalism may have posed threat to building stability in the study area. Hence more than half of the total study participants strongly agreed that all engineering design elements, including mechanical services, can help to further sustain the strength and stability of building projects.

There was a strong correlation between the opinions of the study populations regarding the contributions of poor mechanical services' design and installation to building collapse. In the respondents' opinions, pipe leakages could result from water piping, air conditioning piping and conduct piping which are parts of mechanical elements. Hence, water leakages could cause spillage. According to Ishak et al (2009), spillages will result into dampness to building and this was described by Agyekum et al (2013) as most damaging faults that can occur to building.

Chi-square tests were significant that the working experiences and the work status of the study populations affected their responses on the role played by mechanical installations in building collapse. The years of working experience of the study participants influenced their responses. Most of the affirmation to the relevance of proper design of mechanical engineering services at reducing counts of building collapse were from the key identified stakholders who had spent above 4 years on construction projects. However the status of the various stakeholders had divergent opinions about the contributions of mechanical elements to building collapse. However, major participants in the management cadre (supervisors and the managers) considered the contributions of mechanical services to building stability as relevant.

4. CONCLUSION

This study assessed into the impact(s) of mechanical elements' inclusion in the built industry. It examined whether or not the design and/or installation of mechanical elements in buiding construction projects have significant association with building weakness and/or collapse. From the study, majority of the participants had experienced building collapse and therefore placed a high need on quality services engineers' detail drawings and supervisions. Participants opined that the involvement of services experts can not be underrated if building strenght must be sustained. Some of the mechanical inputs widely highlighted that require adequate attention of experts to prevent weakening of building structures are water pipe, spillages from pipe leakage, conduct piping and soak-away-pit. The result of statistical test ascertained strong correlation between the opinions of the study

populations on the relevance of mechanical services to bilding strenght and sustanance. Other statistical test confirmed that installation of mechanical services when not properly carried out can contribute to building collapse.

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