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Research paper

Analysis of Concrete Structure Calculation Methods Based on SNI 2847-2002 and SNI 2847-2023 using Etabs 21.2.0

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ABSTRACT

Purpose: This study aims to analyze the impact of the regulatory change from SNI 2847-2002 to SNI 2847-2013 on structural concrete, particularly in terms of calculation methods and structural modeling. The update in standards was introduced to enhance concrete quality and align with scientific advancements in structural engineering.

Methods/Design: The research compares manual calculations based on SNI 2847-2002 with analysis conducted using Microsoft Excel in accordance with SNI 2847-2013. The focus is on the dimensions of reinforced concrete beams and the required Ace value (area of tensile reinforcement), which significantly influences structural performance.

Findings: A significant difference in the Ace values was observed between the two standards. This discrepancy arises due to variations in the effective depth (*d*) and the sliding moment formula applied in each version of the standard. These differences directly affect various structural aspects, including flexural strength, stiffness, crack control, and beam deflection.

Practical implication: The transition from SNI 2847-2002 to SNI 2847-2013 has implications not only for technical calculations but also for structural design and safety. Structural engineers must understand and adapt to these changes to ensure their designs comply with updated standards and meet enhanced safety requirements.

INTRODUCTION

Concrete is a mixture of Portland or hydraulic cement with fine aggregate, coarse aggregate, and water, sometimes with admixtures (Alfatari et al., 2021 ; Gracia and Gonzalez

2018). Reinforcement is used in concrete to resist tensile forces, as concrete is strong against compressive forces but weak against tensile forces (Nawy & Edward, 1998). Reinforced concrete contains a minimum-required cylinder and design so that both materials work together to withstand the style (Mulyono, 2004). In Indonesia, reinforced concrete planning standards refer to SNI 2847:2013. Reinforced concrete beams are essential in building construction, especially in multi-storey residential buildings. Reinforced concrete combines concrete (strong in resisting compressive forces) and reinforcing steel (strong in resisting tensile forces). This combination creates a composite material that can withstand various loads and forces in building structures. Reinforced concrete is used in various structural elements such as beams, columns, slabs, and foundations, where reinforced concrete beams, in particular, resist bending and shear loads and transfer loads from floor slabs to columns or load-bearing walls. In concrete planning, Indonesia has regulations and standards that regulate its planning, namely the Indonesian National Standard or SNI.

The Indonesian National Standard (SNI) is a set of regulations established by the National Standardization Agency (BSN) and is legally binding at the national level. These standards are designed to protect and ensure the uniformity of various products, including buildings. In the context of building construction, standardization encompasses all aspects—from initial planning and structural strength calculations to construction practices, testing, and long-term maintenance. On December 17, 2019, BSN officially enacted a revised standard for structural concrete, namely SNI 2847:2013, which superseded the previous SNI 2847:2002 titled *Structural Concrete Requirements for Buildings*. This update was introduced with the intention of enhancing the quality and reliability of concrete structures, while also aligning national practices with ongoing scientific and engineering developments in structural concrete design.

The shift from the 2002 to the 2013 version of the standard holds significant implications, especially in the context of structural safety and serviceability. Because building feasibility must consider both strength and safety criteria, any ongoing or previously planned concrete structure designs based on the older standard may need to be reviewed and revised. This change does not occur in isolation—other related SNI regulations have also been updated. For instance, updates in earthquake-resistant building standards have influenced the response spectrum, leading to increased shear forces in structural elements (Aditya et al., 2021; Sucipto & Sutjipto, 2022). Given these developments, there is a pressing need to evaluate how the transition from SNI 2847:2002 to SNI 2847:2013 affects structural concrete, particularly in terms of analytical calculations and structural modelling practices. This research aims to identify and analyze the key differences between these two standards and assess their practical impact on reinforced concrete behavior, performance, and design parameters.

The transition of structural design codes in Indonesia reflects a broader trend toward harmonizing national standards with international best practices and updated scientific understanding. SNI 2847, which governs the requirements for structural concrete design, is largely adapted from the American Concrete Institute (ACI) 318 standards. The update from SNI

2847:2002 to SNI 2847:2013 corresponds closely with changes seen in ACI 318-08, incorporating more rigorous design procedures and enhanced safety considerations.

Previous studies have noted that one of the most significant changes in SNI 2847:2013 lies in the reformulation of load and resistance factors, revisions in shear and moment calculations, and adjustments to reinforcement detailing. These changes aim to improve structural performance under both static and dynamic loads (ACI Committee 318, 2008). For example, the sliding moment equation and parameters such as the effective depth (d) and area of tensile reinforcement (Ace) were revised, resulting in noticeable differences in structural dimensions and reinforcement requirements (Aditya et al., 2021). In the Indonesian context, Sucipto & Sutjipto (2022) emphasized that the updated concrete standard affects not only the strength design but also building behavior under seismic conditions. When integrated with revised seismic codes (e.g., SNI 1726:2019), the combined effect can result in increased base shear forces and higher structural demands, especially in earthquake-prone areas. These changes necessitate more conservative and robust design strategies.

Moreover, comparative analyses between SNI 2847:2002 and SNI 2847:2013 conducted in various structural modeling software, such as ETABS or SAP2000, show disparities in beam deflection, crack width control, and overall stiffness, all attributed to different assumptions and design methodologies embedded in the two versions (Yulianto & Arifianto, 2020). Such findings underscore the importance of understanding the structural implications of code changes beyond mere numerical differences in reinforcement. Despite growing awareness of these differences, there is still limited empirical research focusing specifically on how manual calculations and digital tools reflect the transition between these two SNIs. Most existing literature focuses either on isolated parameters or on software-based simulations, with few studies providing a comprehensive comparison that integrates manual calculation methods with modeling outcomes based on both standards. This gap highlights the need for research that systematically examines the practical implications of the standard update, especially from a design and engineering decision-making perspective. By exploring these changes in a detailed, comparative manner, this study contributes to a better understanding of how regulatory evolution shapes real-world engineering practices.

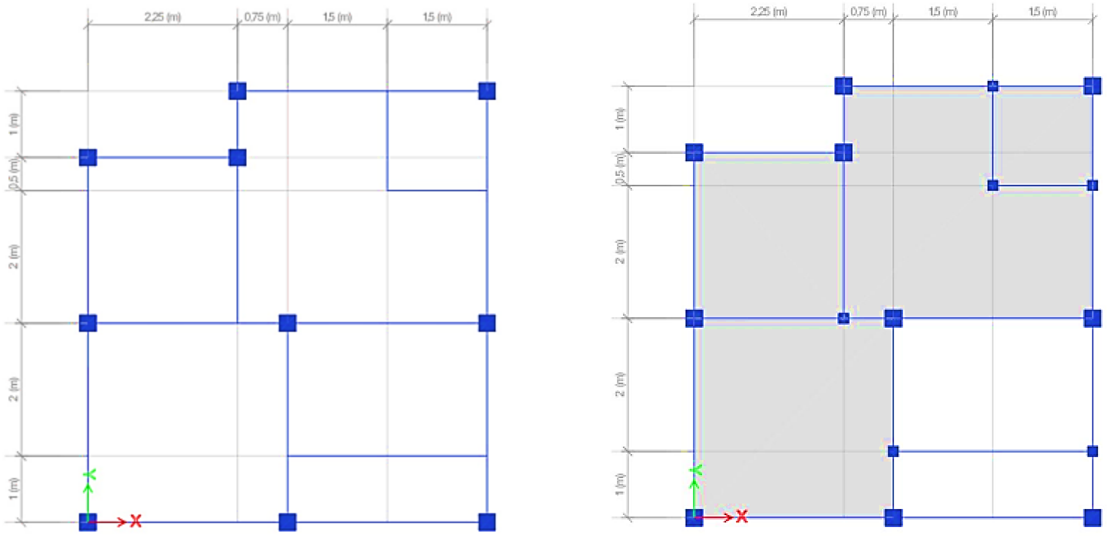
METHODS

1. Case Study Details

The case study refers to the research of (Septiropa, 2009) which discusses the optimization of reinforced concrete beam dimensions in simple multi-storey houses based on SNI 2847-2002. Furthermore, from the same case study as the research and calculations of Septioropa, 2009, we re-analyzed by considering aspects of SNI changes to the latest regulations, namely SNI 2847-2013. This update includes significant changes in calculation methods and technical requirements, which aim to improve the quality and safety of building structures. This case study aims to optimize the dimensions of reinforced concrete beams in a simple multi-storey house using the latest standard, SNI 2847:2013. The main focus is to design beams that meet structural strength and stability requirements and are efficient in material use, resulting in an economical design without compromising safety aspects.

2. Building Beam Planning Data

The building beams are planned by calculating a residential house with type 36, 2 floors, a land area of 80 m2, two bedrooms, a kitchen, a bathroom, and a living room that integrates with the family room. Figure 1 illustrates the house plan, and beam planning data can be seen in Table 1.



(a) (b)

Figure 1 House Floor Plan (Septiropa, 2009) (a) Fist Floor, (b) Second Floor

Table 1 Building beam planning data

No	Data	Vol	Unit
1	Beam thickness (h)	350	Mm
2	Beam width (b)	250	mm
3	Fc’	22.5	MPa
4	Fy	240	MPa
5	Beam span length (L)	3	m
6	Beam width (b)	1.5	m
7	Dead load (qd)	4.07	kN/m^2
8	Live load (ql)	1.25	kN/m^2
9	Beam load	1.38	kN/m^2

3. Structural Calculations

In reinforced concrete planning/calculation, two conditions must be met, namely:

a. The design moment Md must ≥ necessary momen Mu.

b. Concrete compressive strain ε'c must ≤ limit strain ε'cu (0,003).

Calculation of beam longitudinal reinforcement, using the equation:

$$K = \frac{Mn}{bd\hat{}2} \text{ or } K = \frac{Mu}{\phi.\mathrm{b}.\mathrm{d}\hat{}2} \tag{1}$$

$$a = (1 - \sqrt{1 - \frac{2k}{-,85\, f\prime c}}).\ D \tag{2}$$

$$As = \frac{0{,}85\, f'.a.b}{fy} \tag{3}$$

The calculation design moment Md is carried out as follows:

a. The equivalent square concrete compressive stress beam height a is:

$$a = \frac{As\ fy}{0.85.f\prime c.b} \tag{4}$$

b. Actual moment Mn with equation:

$$Mn = Cc.\ (d - \frac{a}{2}) \text{ or } Mn = Ts.\ (d - \frac{a}{2}) \tag{5}$$

Then the design moment Md = θ. Mn with θ = 0,9

The equation calculates the concrete compressive strain:

$$\varepsilon'c = \frac{a}{\beta 1.d}\ \varepsilon'y \tag{6}$$

With the condition that it must be $\leq 0{,}003$

4. Structural Modelling

The structural analysis uses two methods: manual calculation of beam design using Microsoft Office Excel and structural design modelling using the ETABS 21.2.0 application. Finite element-based computer calculations for various loading combinations, including dead and live loads, are combined with 3D structural modelling. The input of ETABS structural planning data is based on the Indonesian Loading Regulations for Buildings 1983.

FINDINGS

1. Research Data Load Calculation

Dead load is the weight of all fixed parts of a building, including all ancillary elements, finishes, machines, and fixed equipment that are integral to the building. The dead load on this multi-storey house planning is:

a. Floor 0,24 kN/m^2 = 0,24 kN/m^2 a) Weight of Floor Covering 0.24 kN/m^2 = 0.24 kN/m^2
b. Weight of Speci Mix 0.21 kN/m^2 = 0.21 kN/m^2
c. Weight of backfill Sand 16 kN/m^3 x 0.05 m = 0.8 kN/m^2
d. Self Weight of Concrete Plate 24 kN/m^3 x 0.11 m = 2.64 kN/m^2
e. Ceiling Hanging Weight 0.07 kN/m^2 = 0.07 kN/m^2
f. Weight of Frame and Ceiling 0.11 kN/m^2 = 0.11 kN/m^2
g. Total = 4.07 kN/m^2
h. Live load for simple Residential Building Use Load = 125 kN/m^2 = 1.25 kN/m^2

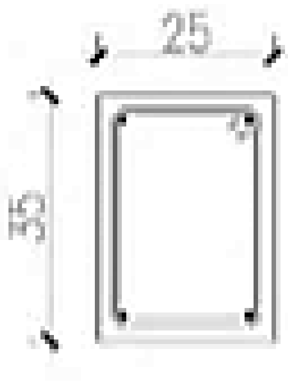
2. Data Analysis And Calculation Regarding SNI 2847-2013

Calculations carried out using the formula and reference SNI 2847-2013 obtained the following values:

Table 2 Excel Calculation Results

Ultimate uniform load (qu)	8,54 kN/m2
Necessary moment in the beam (Mu)	96,067,500 Nmm
Design moment in the beam (Md)	24,930,000 Nmm
Plan moment in the beam (Mr)	18,165,247.85 Nmm
Bending moment (k)	0.44 Mpa
Quantity of Reinforcement (n)	3D12 Where made into 4D12 with 2 compressive reinforcement and 2 tensile reinforcement
Reinforcement ratio	0.0062 with qualified > ρmin which is 0.005 and < ρmax which is 0.04.

Table 3 Beam cross-section details

Type	Pedestals
Beam 25/35	
Concreate ducking	40 mm
Tensile reinforcement and compressive reinforcement	2Ø12
Begel	-

In addition to performing the analysis by calculation, further analysis was carried out using ETAPS with the load combination used 1.2D +1.2 SDL + 1.6L. Planning is carried out on the house's structure according to the plan, and the results can be seen in Figure 3. The moments usually wanted to be obtained on the beam are the pedestal area ¼ span and the field area ½ span. Mu = 6.2 kN / m in the middle of the span, and the value of Mu = -7.8 kN / m at the end of the span. Table 3 describes the beam element loads in ETAPS 21.2.0 calculations.

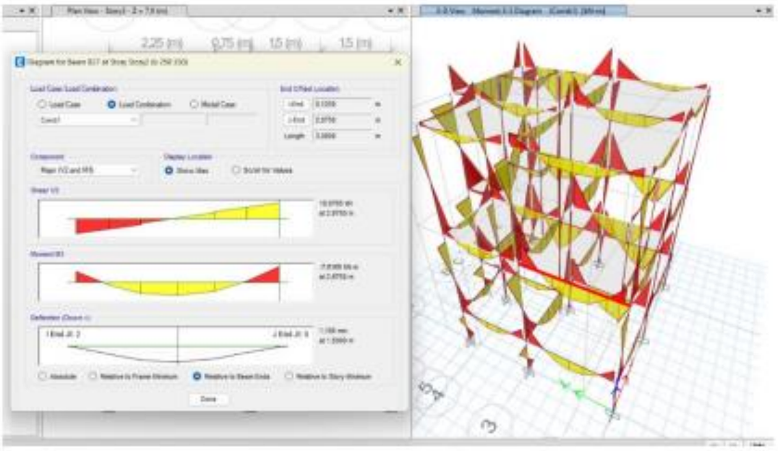
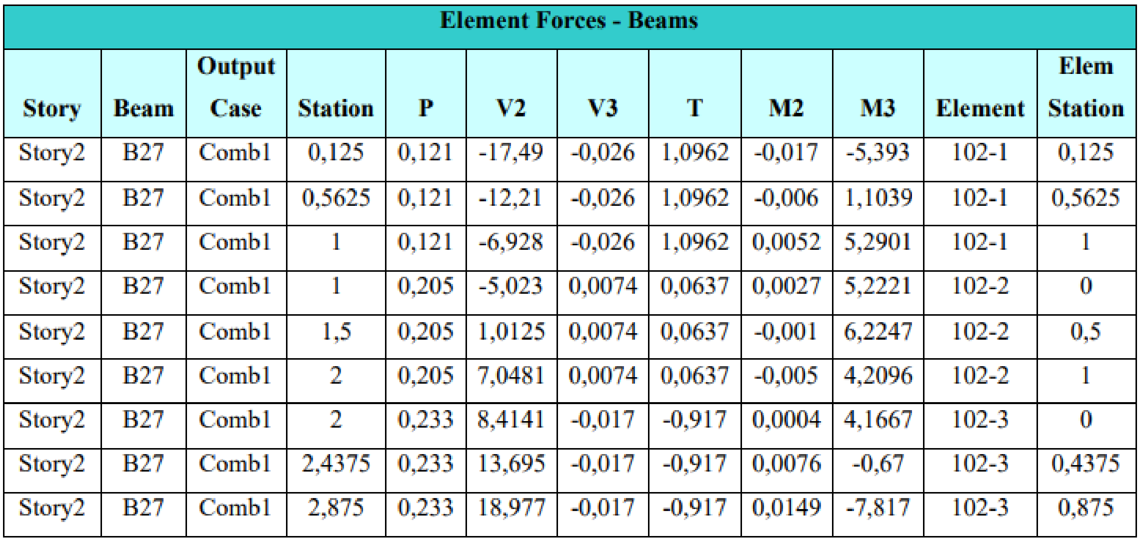


Figure 2 Result ETAPS

The figure shows the results of structural analysis using ETABS software, where moment, shear and deflection diagrams of one of the beams on the second floor of a multi-storey building structure are shown. Based on the displayed internal force diagram, it can be seen that the beam experiences the maximum moment at mid-span as well as the maximum shear force near the pedestal, which is indicated by the red-colored area as an indication of extreme values. The maximum deflection of the beam was recorded at 1,306 mm, which is still within the service tolerance limit of the structure. The analysis utilizes a combination of loads, which reflects the actual condition of the structure under the simultaneous influence of dead, live, and lateral loads. These results provide important information for the reinforcement planning process and evaluation of the structure's performance against safety and comfort criteria in accordance with applicable planning standards.



Element Forces - Beams											
Story	Beam	Output Case	Station	P	V2	V3	T	M2	M3	Element	Elem Station
Story2	B27	Comb1	0,125	0,121	-17,49	-0,026	1,0962	-0,017	-5,393	102-1	0,125
Story2	B27	Comb1	0,5625	0,121	-12,21	-0,026	1,0962	-0,006	1,1039	102-1	0,5625
Story2	B27	Comb1	1	0,121	-6,928	-0,026	1,0962	0,0052	5,2901	102-1	1
Story2	B27	Comb1	1	0,205	-5,023	0,0074	0,0637	0,0027	5,2221	102-2	0
Story2	B27	Comb1	1,5	0,205	1,0125	0,0074	0,0637	-0,001	6,2247	102-2	0,5
Story2	B27	Comb1	2	0,205	7,0481	0,0074	0,0637	-0,005	4,2096	102-2	1
Story2	B27	Comb1	2	0,233	8,4141	-0,017	-0,917	0,0004	4,1667	102-3	0
Story2	B27	Comb1	2,4375	0,233	13,695	-0,017	-0,917	0,0076	-0,67	102-3	0,4375
Story2	B27	Comb1	2,875	0,233	18,977	-0,017	-0,917	0,0149	-7,817	102-3	0,875

Figure 3 Result from ETABS

Based on the analysis that has been carried out using Microsoft Excel and ETAPS 21.2.0, there are some differences in the calculation results that have been obtained, among others, the load obtained by the beam, shear (strain), and moment on the beam with details shown in Table 4.

Table 4 differences in the calculation results using Excel and ETAPS

No	Differences	Excel	ETAPS 21.2.0
1	Load obtained by the beam	8.54 kN/m’	8.004 kN/m’
2	Shear	Not calculated	0
3	Moment in Beam	9.6075 kNm	4.9388 kNm

3. Analysis Of Differences Between SNI 2847-2002 And SNI 2847-2013

The results of the analysis show several differences in the formula between SNI 2847-2002 and SNI 2847-2013, as shown in Table 5.

Table 5 differences in the formula between SNI 2847-2002 and SNI 2847-2013 ([BSN] Badan Standarisasi Nasional, 2002, 2013)

INDICATORS	SNI 2847-2002	SNI 2847-2013
Bending Moment	$Mn = As.fy(d-\frac{a}{2})$ $a = \frac{As.fy}{0,85\, f'c.b}$	$Mn = As.fy(d-\frac{a}{2})$ $a = \frac{As.fy}{\beta 1\, f'c.b}$
Shear Capacity	Vn = Vc +Vs $Vc = 0,17\sqrt{f'cbwd}$ Vs is the contribution of shear reinforcement	Vn = Vc+ Vs $Vc = 0,17\sqrt{f'cbwd}$ Or $Vc = 0,29\sqrt{f'cbwd}$

		for condition without shear reinforcement
Crack Control	$wmax = \frac{2\sigma(dc + 0,5s)}{Es}$	$wmax = \frac{ptfs(dc + s/2)}{Es}$
Beam Deflection	$\Delta = \frac{5wL\text{\^{}}4}{384EI}$	$\Delta = \frac{5wL\text{\^{}}4}{384EIe}$
Reinforcement Minimum	$As \geq \frac{0,25\, f'c.b.d}{fy}$	$As \geq 0,0018.b.h$ Where b is the width of the beam and h is the total height of the beam

Table 5 shows that there are differences between SNI 2847-2002 and SNI 2847-2013 in terms of the calculation of reinforced concrete beams. The change in bending moment between the two standards shows the variation in concrete quality. Regarding shear capacity, SNI 2847-2013 increases flexibility and safety compared to SNI 2847-2002. Controlling the maximum crack width and minimum reinforcement requirements provides details to ensure that each beam has a minimum amount of reinforcement sufficient to cope with the base flexural load. This approach reduces the risk of failure and ensures the structure remains safe and stable under various load conditions.

In the calculation using SNI 2847-2002, the value of As needs to be 162.34 mm2. While the calculation results using SNI 2847-2013 obtained a value of As need of 382.932 mm2. There is a significant comparison with a difference of 220.592 mm2. This is due to the difference in the value of d (Longitudinal Beam Reinforcement). In the journal, the value of d is obtained at 281.5mm with the formula d = h - concrete blanket - ½ diameter of the central reinforcement rent. In Excel calculations, the value of d is obtained at 310 mm with the formula d = h -ds. In addition, the difference in the bending moment formula also affects the calculation of the required As. The As value used affects various aspects of structural performance, including flexural strength, stiffness, crack control, and beam deflection. Using too small or too large each has significant advantages and disadvantages for structural safety. The following are the effects of small and large As values on reinforced concrete beams:

A. As Value that is too Small
   1. Flexural Strength
      Insufficient steel reinforcement may cause the beam to be unable to resist the bending moment generated by the applied load. This situation can lead to flexural failure, where the concrete in the tensile section cracks and the steel reinforcement is insufficient to resist the stresses. In addition, flexural failure may occur earlier than planned (Wahiddin et al., 2022).
   2. Poor Crack Control

Insufficient reinforcement can lead to greater crack width in concrete. Excessive cracking can also reduce the beam's stiffness and the structure's overall performance (Noorhidana & Purwanto, 2011).

3. Excessive Deflection

   Lack of steel reinforcement can cause excessive deflection in the beam. Excessive deflection can compromise occupant comfort, mainly if the beam is used on a frequently passed or occupied floor (purnamasari, 2017).

B. As Value that is too Large

1. Inefficient Cost

   Excessive use of steel reinforcement increases material costs significantly. Increasing the amount of reinforcement can also increase the cost of the work, including installing and compacting the concrete around the reinforcement.

2. Construction Difficulties

   Too much reinforcement can make it difficult to place and compact concrete around the reinforcement, which can cause honeycombing and reduce concrete quality. Difficulties in reinforcement placement and concrete compaction can result in poor quality control, potentially reducing the long-term performance of the structure.

3. Increase in Self-load

   The addition of steel reinforcement also increases the dead load of the beam. While this may not be significant in some cases, in large structures or with other additional loads, the increase in dead load can affect the structure's overall design.

4. Over-Reinforced Section
5. Beams with too much reinforcement can become over-reinforced, where the steel reinforcement reaches yield stress after the concrete in the compressive section has collapsed (Apryanto & Hartopo, 2022).

SUMMARY

Based on the results and discussions that have been carried out, several conclusions can be drawn, including:

1. In the dimensional analysis of reinforced concrete beams, there is a significant difference between the necessary As value obtained through a manual calculation based on SNI 2847-2002 and analysis using Excel based on SNI 2847-2013. This difference is caused by variations in the value of d (Beam Longitudinal Reinforcement) and the bending moment formula used. The required As value affects various aspects of structural performance, including flexural strength, stiffness, crack control, and beam deflection.
2. Analysis using Microsoft Excel and ETAPS 21.2.0 showed differences in the beam's calculation of load, shear, and moment. Excel produced a beam load of 8.54 kN/m' and a moment of 9.6075 kNm, while ETAPS 21.2.0 showed a load of 8.004 kN/m', a strain of 0, and a moment of 4.9388 kNm.

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