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Redesign of the Sophos School Indonesia BSD School Building Using a Steel Structure with a Special Moment Bearing Frame Structure Method

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Abstract: The redesign of the Sophos School Indonesia, BSD School Building was carried out using a steel structure with a Special Moment Resisting Frame (SRPMK) system in accordance with SNI 1726:2019, SNI 1727:2020, and SNI 1729:2020. This study aims to determine the dimensions of the steel profile and evaluate the structural performance against earthquake loads and other loads through the Load and Resistance Factor Design (LRFD) method with ETABS software. The object of the study is a 4-story school building with a height of 19.55 m with a span of 28.8 m × 18 m and a main structure of BJ-41 quality steel beams and columns. The loads calculated include dead, live, wind, and earthquake loads. The analysis results show that the steel profile used meets the safety requirements, with mass participation achieved in the 18th mode, maximum inter-story drifts of 39.472 mm (X) and 34.639 mm (Y) which are still below the SNI limit, and the P-Delta effect shows a stability ratio <0.1. Thus, this four-story school building is feasible to be built using a steel structure with the SRPMK system, which meets Indonesian earthquake resistance standards.

Keywords: Steel Structure, SRPMK, ETABS, LRFD, Earthquake.

INTRODUCTION

Infrastructuredevelopment in Indonesia continues to grow, while limited land availability encourages the emergence of high-rise buildings. Indonesia's geographical location at the confluence of three major global plates makes it prone to earthquakes, requiring careful planning of building structures to ensure they are safe from earthquakes and other loads. In this regard, material selection, as well as the dimensions of columns and beams as the primary load-bearing elements, are crucial factors determining a building's strength, efficiency, and safety. Steel is considered a superior material for structures in earthquake-prone areas due to its higher strength and ductility than concrete. The Load and Resistance Factor Design (LRFD) method, a modern approach to steel structure design, statistically calculates serviceability and ultimate limits, thereby enhancing the reliability of structural designs.

However, the use of steel structures in Indonesia is still limited compared to other countries. Therefore, this research was conducted as a case study with the title

"Redesigning the Sophos School Indonesia BSD Building Using a Steel Structure with the Special Moment Resisting Frame Method". The purpose of this study is to analyze and determine the dimensions of the steel structure profile using the Special Moment Resisting Frame (SRPMK) system, as well as to find out the results of the analysis and discussion related to the control of base shear forces, mass participation, deviations due to dynamic earthquakes, and structural examination of the influence of P-Delta. The results of the research are expected to provide a safe, efficient steel structure design, and in accordance with applicable planning standards, while also broadening the understanding of the potential use of steel structures in high-rise buildings in Indonesia.

LITERATURE REVIEW

The moment-resisting frame system (SRPM)

The moment-resisting frame system (SRPM) is a structural system widely used in the design of multi-story buildings, particularly in earthquake-prone areas. This system relies on the flexural capacity of beam and column elements, where the connections between elements are rigidly constructed to withstand both gravitational and lateral loads caused by earthquakes. The primary advantage of the SRPM is its architectural flexibility, as it eliminates the need for shear walls or braces to resist lateral forces. Based on their ductility levels, SRPMs are divided into three categories:

1. Ordinary SRPM (SRPMB) has low ductility and is generally used in areas with low earthquake risk.
2. SRPMM has partial ductility with intermediate structural detailing.
3. SRPMK is a fully ductile system with the most stringent detailing requirements in accordance with SNI 1726:2019. This system is designed to be ductile, capable of absorbing large amounts of earthquake energy without causing sudden collapse. Therefore, SRPMK is considered the most suitable structural system for use in areas of Indonesia with high levels of seismicity.

Steel Structures

Steel structures have high tensile and compressive strength, good ductility, and advantages in construction speed and material efficiency, making them highly suitable for use in earthquake-resistant buildings. According to Simbolon (2018), steel is superior to reinforced concrete because it can absorb earthquake energy more effectively. However, despite these advantages, the use of steel structures in Indonesia remains limited due to cost, material availability, and planners' preference for concrete systems.

Material and Mechanical Properties of Steel

Steel is an alloy of iron and carbon. A high carbon content increases steel's strength but decreases its ductility. When used as a structural material, the mechanical properties of steel are a crucial consideration.

Tensile testing is the standard method for determining the mechanical properties of steel. The results of this test produce a stress-strain curve that shows the elastic, plastic, strain-hardening, and ultimate stress phases. Based on this curve, steel with a low yield stress is generally more ductile than high-strength steel.

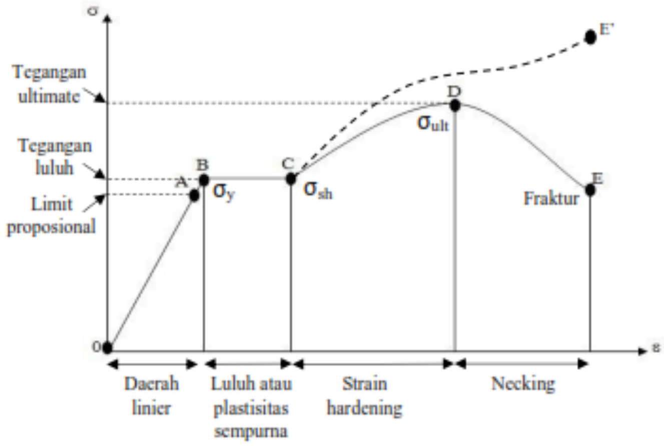

Figure 1. Steel stress and strain diagram

Source: https:www.sipilpedia.com

When the strain approaches the yield point (σy), the state is said to be elastic. A plastic state ranging from σy to σsh occurs. After that, strain hardening occurs. In the strain hardening state, the stress increases from σsh to σult, instead of remaining constant. The stress at σult is the highest on this curve, so it is called the "ultimate stress" (Dewobroto, 2015).

In designing steel structures, SNI 03-1729-2020 takes several mechanical properties from the same material, namely:

Modulus of Elasticity, E	= 200,000 MPa
Shear Modulus, G	= 80,000 MPa
Poisson's Ratio	= 0.30
Coefficient of Linear Expansion, ct	= 12.10 -6/°C

SNI 03-1729-2020 concerning the structural and mechanical properties of steel buildings states that the yield stress (fy) and breaking stress (fu) for planning purposes must not exceed the values listed in the following table.

Table 1. Mechanical properties of structural steel

Steel Type	Minimum breaking stress, f_u (MPa)	Minimum yield stress, f_y (MPa)	Minimum Stretch (%)
BJ 34	340	210	22
BJ 37	370	240	20
BJ 41	410	250	18
BJ 50	500	290	16
BJ 55	550	410	13

(Source: SNI 03 – 1729 – 2020)

Loads on a structure consist of dead load, live load, and earthquake load. Dead load is the weight of all permanent components of a building, including structural elements, installations, and fixed equipment that remain constant throughout the building's lifespan. Live load originates from occupant activities and building use, such as the weight of people, furniture, vehicles, and other movable objects. Therefore, its nature varies and must be determined according to building function standards. Meanwhile, earthquake loads arise from both vertical and horizontal ground movement, with horizontal influences being more dominant due to the greater lateral ground acceleration. The magnitude of the base shear force caused by an earthquake can be calculated using the equivalent static formula:

$$V = \frac{c \, x \, l}{R} \text{ x } Wt_1,$$

where c factors are determined based on site conditions, soil type, building characteristics, and the structural system used. All provisions regarding this loading refer to SNI 1727:2020 and SNI 1726:2019.

Dead load (DL)

Dead load is a permanent load originating from the weight of the building structure itself and its firmly attached permanent components, such as architectural finishing, ducting, cables and M/E pipes, all of which are calculated as additional dead load based on the following Table 2:

Table 2. Dead load

NO	MATERIAL	UNIT	WEIGHT
1	Steel	7850	kg/m^3
2	Reinforced Concrete	2400	kg/m^3
3	Mixes / screed per cm thick	21	kg/m^2
4	Ceiling and frame	18	kg/m^2
5	Floor finishing per cm thickness	24	kg/m^2
6	Light Bricks	650	kg/m^3

(Source: PPIUG in 1987)

Live Load (LL)

Live load is the load generated by the users and occupants of a building or other structure and does not include construction loads. The magnitude of the live load and its reduction comply with the provisions of SNI 1727:2020 "Minimum Loads for the Design of Buildings and Other Structures."

Table 3. Living Burden

NO	TYPE OF LIVE LOAD	UNIT	WEIGHT
1	Non-residential roof	97,9	kg/m^2
2	Floors of school building	195.79	kg/m^2

(Source : SNI – 1727 – 2020)

Rain Load (R)

According to SNI 1727:2020, there has been a significant increase compared to previous provisions, especially for sloping steel roofs that are not designed for human access, with a minimum value of not less than 0.58 kN/m^2.

Wind Load (W)

Wind load is the force generated when wind hits a building, exerting pressure and suction on the structure. According to SNI 1727-2020, for closed, partially closed, and open buildings of all heights, the steps are as follows:

Step 1: Determine the building's risk category.

Step 2: Determine the basic wind speed, Vv. For the applicable risk category, see the Indonesian Wind Map Book.

Step 3: Determine the wind load parameters:

- Wind direction factor, Kd
- Exposure category
- Topography factor, Kzt
- Ground elevation factor, Ke

• Wind gust effect factor, G or Gf

• Enclosedness classification

• Internal pressure coefficient

Step 4: Determine the velocity pressure exposure coefficient, Kz or Kh

Step 5: Determine the velocity pressure, qz or qh

Step 6: Determine the internal pressure coefficient, Cp or Cn

Step 7: Calculate the wind pressure, p, on each surface of the building.

Earthquake Load (E)

Earthquake loads are the forces acting on a structure due to ground movement during an earthquake. Planning references refer to SNI 1726-2019.

• Soil Site Classification

• Determined based on shear wave velocity (Vs), N-SPT value, and soil shear strength (Su).

• Soil categories: SA (hard rock), SB (rock), SC (hard soil), SD (medium soil), SE (soft soil), SF (special soil).

• Spectral Response Parameters

• Site amplification factors: Fa (short period) and Fv (1-second period).

• MCER parameters: SMS and SM1, then derived into design parameters:

o Sds = 2/3 SMS

o Sd1 = 2/3 SM1

• Design Response Spectrum

• Determined based on the fundamental period of the structure (T).

• Divided into 3 conditions: $T < T0$, $T0 \leq T \leq Ts$, and $T > Ts$.

• Seismic Design Category (SDC)

• Determined from the Sds and Sd1 values and the building's risk classification.

• SDC: A (low), B–C (medium), D (high).

• Earthquake Resistance System

• Uses a framing system (e.g., a special moment-resisting steel frame).

• Important factors: R (response modification), Ω0 (overstrength factor), and Cd (deflection magnification factor).

• Fundamental Period (Ta)

• General formula: $Ta = Ct \times H^x$ (H = building height).

- Alternative: Ta = 0.1N for structures ≤ 12 stories.
- Basic Seismic Force (V)
- Formula: V = Cs × W
  - o Cs = seismic response coefficient
  - o W = effective seismic weight
- Cs is limited by minimum and maximum values according to SNI.
- Vertical Distribution of Seismic Forces
- Lateral seismic forces on each floor are calculated as:

  Fx = Cvx × V,

where Cvx is proportional to the floor weight (Wi) and floor height (hi).

RESEARCH METHOD

In the research on the redesign of the Sophos School Indonesia BSD School Building using the special moment resisting frame (SRPMK) steel structure, the calculation stages were carried out systematically.

The process began with data collection including building dimensions, steel quality, preliminary design results, and supporting literature. The collected data was then used to conduct a load analysis to obtain an overview of the loads acting on the structure. The next stage was structural analysis using ETABS V21 software. The results of this analysis were then checked through the section check stage (check ETABS). If the check results indicate that the section does not meet the requirements, recalculation and analysis were carried out until appropriate results were obtained. Conversely, if the section has been declared to meet the requirements, the study continued with drawing conclusions. Thus, this series of processes ensured that the planned steel structure design was able to meet the applicable building structure planning requirements.

The redesign of this school building is located at Jl. Boulevard BSD Timur No. 29, Rw. Buntu, Serpong District, South Tangerang City, Banten, with the postal code 15310. The planned project is the construction of a four-story school building using the Special Moment Resisting Frame (SRPMK) structural system. The building's primary function is as an educational facility, so the structural design must consider aspects of safety, strength, and earthquake resistance in accordance with applicable standards.

To guide the structural design, design criteria and general information are established, covering regulatory standards, material types and quality, superstructure and foundation systems, and the analysis and modeling methods used. The regulations used for the planning are SNI 1727:2020 concerning Indonesian Loading Regulations for Buildings, SNI 1726:2019 concerning Procedures for Earthquake Resistance Planning for Buildings, and SNI 1729:2020 concerning Procedures for Steel Structure Planning for Buildings. By adhering to these standards, it is hoped that the building structure can meet the safety and reliability requirements according to applicable technical provisions.

RESULT AND DISCUSSION

Building Configuration

The Sophos School Indonesia building has four floors: the first, second, third, and fourth floors, and a roof truss. The configuration data for the Sophos School Indonesia building to be redesigned is as follows:

1. Building Type: Multi-storey building
2. Structural Type: First floor columns – steel-concrete composite roof, first floor beams – steel structure roof
3. Office Function: School
4. Location: Bumi Damai Serpong, South Tangerang
5. Height: 19.55 m

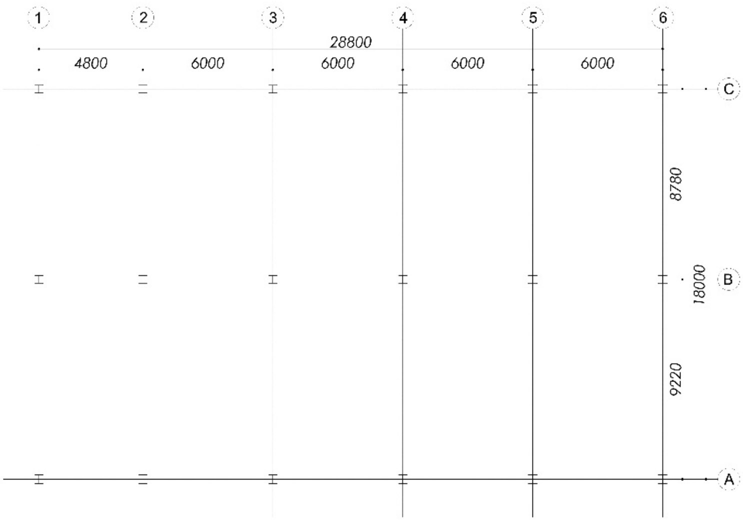

Figure 2. Building plan plans

Source: Researcher 2025

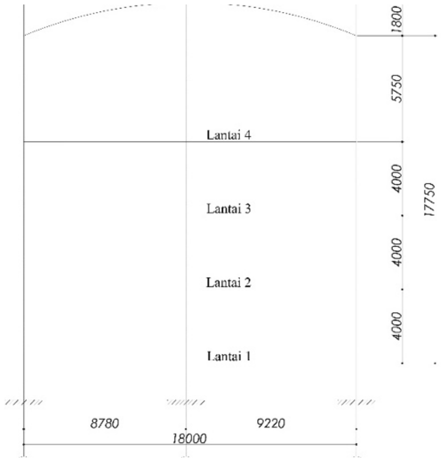

Figure 3. Building plan fragment

Source: Researcher 2025

Material Data

The material data used in the steel structure design are as follows:

1. Steel profile quality: BJ41 (Fy = 250 MPa; Fu = 410 MPa)
2. Bolt quality: A 325

Preliminary Design

The preliminary design stage is the initial step in structural planning, aiming to determine the estimated cross-sectional dimensions of beams and columns before conducting more detailed analysis. This study used PT Lautan Steel Indonesia's steel profiles as the initial planning reference.

The initial beam design is carried out by estimating the beam cross-section based on the ratio between the beam span length and the profile height. For the main beam, the profile height (H) is determined at 1/20 of the span length (L), while for the sub-beam it is determined at 1/25 of the span length. The profile width (B) is determined at half the profile height (H). The results of the initial calculations are shown in Table 4.2 which contains the estimated dimensions of the steel beam cross-section.

Table 3. Estimation of steel beam profile cross-section

Beam Type	L (mm)	H (mm)	B (mm)	A (mm2)	Disposable Steel Profile
B1	9220	500	200	114,23	IWF 500 x 200
B2	8780	450	200	96,8	IWF 450 x 200
B3	6000	300	150	46,78	IWF 300 x 150
B4	4800	250	125	37,66	IWF 250 x 125
BA1	6000	250	125	37,66	IWF 250 x 125

Beam Type	L (mm)	H (mm)	B (mm)	A (mm2)	Disposable Steel Profile
BA2	4800	200	100	27,16	IWF 200 x 100
BA3	4610	200	100	27,16	IWF 200 x 100
BA4	4390	200	100	27,16	IWF 200 x 100

Source: Researcher 2025

This provides a basis for selecting column profiles for subsequent analysis.

Number of floors (N) = 4

Length of span supported by columns (L1) = 9.22 m

Length of span supported by columns (L2) = 6.00 m

Estimated load per m2 of floor supported by columns = 0.196 kg/cm2

Steel stress (Fy) = 250 Mpa = 2550 kg/cm2

Reduction factor ϕ = 0.9

$$A = \frac{Pu}{\phi\ Fy\ baja}$$

Where:

A = Required steel cross-sectional area (mm2)

Pu = Factored axial force (N)

ϕ = Strength reduction factor (for steel columns generally ϕ = 0.9)

Fy = Yield stress of steel (N/mm2)

Therefore, the H-Beam column steel profile is used 400 x 400 x 13 x 21 with A = 218.7 cm2 ≥ 188.98 cm2

From the preliminary design calculations that have been carried out, a layout plan for themain beam, child beam and column structures was obtained as shown in Figure 4 below.

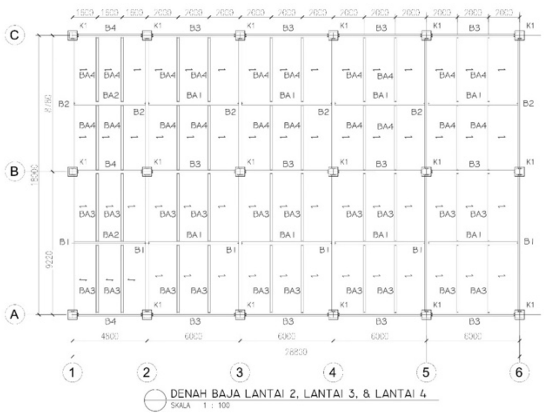

Figure 4. Building plan fragment

Source: Researcher 2025

Analysis and Discussion

Using the LRFD (Load and Resistance Factor Design) analysis method to redesign the structure of a four-story school building in BSD. This is explained in SNI 1729-2020, the Specification for Structural Steel Buildings, adopting AISC 360-16.

Structural Modeling & Analysis

This Etabs modeling is performed to analyze the superstructure loads that will be supported by beams and columns to obtain the maximum profile to support the loads. The following is a superstructure modeling using Etabs, as shown below.

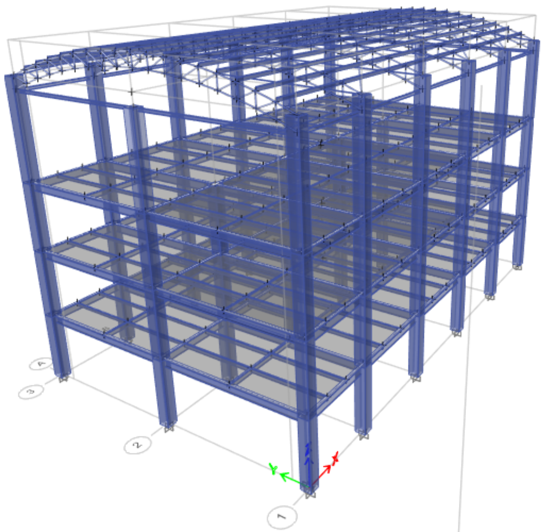

Figure 5. 3D Isometric View

Source: Researcher 2025

Loading Data

In the structural analysis of the case study of the redesign of a 4-story school building in BSD, the calculated loads consisted of dead loads, surcharged dead loads, and other loads in accordance with design standards. Dead loads were automatically determined by ETABS software based on the models and dimensions of the input structural elements, such as columns, beams, floor slabs, and other structural components.

Dead loads

Surcharged dead loads included MEP equipment and permanent loads not directly modeled, such as walls, floors, and ceilings. On the beam, the load comes from a 15 cm thick hebel brick wall with a height of 3.5 m on the 2nd and 3rd floors and 4.5 m on the

4th floor. With a specific gravity of 170 kg/m² (1.67 kN/m²), the wall load is 5.85 kN/m² for the 2nd and 3rd floors, and 7.51 kN/m² for the 4th floor.

Additional loads on the floor slab are calculated according to the 1987 PPIUG, namely floor finishing 0.24 kN/m², 2 cm thick screed 0.41 kN/m², ceiling and frame 0.17 kN/m², and MEP work 0.25 kN/m².

Meanwhile, additional loads on the roof include a zincalume roof of 0.048 kN/m², roof insulation of 0.0004 kN/m², ceiling and frame of 0.17 kN/m², and MEP work of 0.25 kN/m².

Live Load

Input live loads on the second and third floor slabs based on the use or function of the building floors. These loads are regulated in SNI 1727-2020.

Table 4. Live load of floors 2 and 3

No	Use	Heavy	Information
1	2nd and 3rd floors of the school building	1,92kn/m^2/195.79kg/m^2	Classroom

Source: Researcher 2025

Roof Live Load

Input live load on the roof slab based on the use or function of the building's roof. This load is regulated in SNI 1727-2020.

Table 5. roof live load

No	Use	Heavy	Information
1	Roof flooring	0,96 kn/m^2 / 97,9 kg/m^2	Non-residential roofs

Source: Researcher 2025

Rain load

The rain load on building roofs according to SNI 1727-2020 has increased significantly compared to the previous regulation. The old regulation only allowed the rain load to 0.2 kN/m². The new regulation sets the load at 0.96 kN/m², with the possibility of reducing it to a minimum of 0.58 kN/m². Consequently, the design load value used is almost three times greater and directly impacts the planning of roof structure dimensions.

Wind load

The first step in calculating wind loads is determining the building's risk category. According to SNI 1727-2020, school buildings fall into risk category III because structural failure could pose a significant risk to human safety.

The second step is to determine the basic wind speed according to SNI 1727-2020. Basic wind speed (V) is determined based on the Indonesian Wind Map Book for buildings and structures according to risk category. Based on data from the BMKG, the average wind speed in the Banten region is 36 m/s, which is then used as a reference in calculating wind loads on buildings.

Step 3 establishes the wind parameters in accordance with SNI 1727:2020, namely the wind direction factor Kd=0.85for the Main Wind Force Resisting System (MWFRS), exposure category **B** (urban/suburban roughness), topographic factor Kzt=1.0, and ground elevation factor Ke=1.0 with the site elevation in Tangerang City at approximately 14 m above sea level. The building is classified as **enclosed**, therefore the internal pressure coefficient applied is GCpi=−0.18, while the gust effect factor for rigid structures is taken as G=0.85. These parameters serve as the basis for determining wind speed pressure and the distribution of wind loads on the building elements.

Step 4 To determine the values of Kh for the construction of the four-story school building extension, linear interpolation was applied since the building heights were not directly listed in the SNI 1727-2020 reference tables. Based on the interpolation results, the Kz values for each story were obtained as follows: at 4 m (1st floor) Kz=0.57; at 8 m (2nd floor) Kz=0.67; at 12 m (3rd floor) Kz=0.76; and at 16 m (4th floor) Kz=0.85. These values are then used in the calculation of wind loads on the building structure.

Step 5 The wind velocity pressure was calculated using the equation = 0.613. kz. kzt . kd. Ke. V^2. The calculated values of qz were 0.38 kN/m² at the 1st floor, 0.45 kN/m² at the 2nd floor, 0.51 kN/m² at the 3rd floor, and 0.57 kN/m² at the 4th floor. The velocity pressure at the average roof height was taken as qh=qz

Step 6 Based on SNI 1727:2020, the external pressure coefficient for the windward wall (positive pressure) is 0.8, while the external pressure coefficient for the leeward wall (suction) is 0.5.

In step 7, the wind load calculation was carried out using the equation P=qz·G·Cp, where the parameters consist of wind pressure at height Z, gust factor, and wall pressure coefficient. The results show that the wind pressure load on floors 1 to 4 ranges between

0.26–0.39 kN/m², while the suction wind load ranges between **0.16–0.24 kN/m²**. Consequently, the total wind load at the center of mass for each floor is obtained as **0.42 kN/m² on the 1st floor**, **0.50 kN/m² on the 2nd floor**, **0.56 kN/m² on the 3rd floor**, and **0.63 kN/m² on the 4th floor**. In addition to calculations using **SNI 1727-2020**, wind loads on the center of mass in both X and Y directions were also determined using **ASCE 7-16**. The calculation applies the formula P=h/2·W·P (for X direction) and P=h/2·L·P (for Y direction), where *h* is story height, *W* is building width, *L* is building length, and *P* is the combined wind pressure from suction and compression at each floor. From this process, the **X-direction loads** were obtained as **33.27 kN, 38.26 kN, 52.93 kN, and 32.65 kN** for floors 1 through 4 respectively. Similarly, the **Y-direction loads** were **53.24 kN, 61.22 kN, 84.69 kN, and 52.24 kN** for floors 1 through 4. These manual results were then compared with those generated by **ETABS software**, which showed values of **36.49 kN, 39.78 kN, 51.83 kN, and 32.69 kN** for the X direction, and **58.39 kN, 63.66 kN, 82.92 kN, and 52.31 kN** for the Y direction. Although slight numerical differences were found, the overall trends and magnitudes are consistent, indicating that the manual calculation and software results are in good agreement.

Earthquake load

According to the guidelines set out in SNI 1726-2019 concerning the earthquake resistance planning process for building and non-building structures, there are aspects that must be considered when designing earthquake loads to determine seismic loads.

Table 5. Spectrum response data

Fungsi bangunan	Bangunan Sekolah
Katergori resiko bangunan	IV
Faktor keutamaan gempa	1,5
Ss	0,8779
S1	0,4193
Kelas situs	SE
Fa	1,1488
Fv	1,8807
Sms	1,008566636
Sm1	0,78857751
Sds	0,6724
Sd1	0,5257
T0	0,2578
Ts	1,289
KDS	D

Source: Researcher 2025

Control period Fundamental approach

Lower limit :

Tmin = Ct x H^x

= 0,0724 x $19{,}55^{0{,}8}$

= 0,7810

Upper limit :

Tmax = Cu x Ta

= 1,4 x 0,7810

= 1,093

Natural vibration time from Etabs analysis results

Tcx = 0.960 seconds (Etabs output in the X direction)

Tcy = 0.810 seconds (Etabs output in the y direction)

Based on SNI SNI – 1726 – 2019 article 7.8.2 page 55:

If Tc > Cu.Ta then T = Cu.Ta

If Ta < Tc < Cu.Ta then T = Tc

If Tc > Cu.Ta then T = Ta

Structural Behavior Control

Table 6. Base Shear

Tipe Gempa		Fx	Fy	100% statik X	100% statik Y
Statik	EQsx	1119,7	0	1143,9	1143,9
	EQsy	0	1119,7	1143,9	1143,9
Dinamik	EQdx	1238,0	4,7	**DINAMIS**	**DINAMIS**
	EQdy	3,1	1407,5		

Source : output Etabs 2021 – *show table – analisis result – struktur output – base reaction*

Mass participation control

Table 7. Modal mass participation ratio

Case	Mode	Period *Sec*	UX	UY	UZ	Keterangan
Modal	1	0,96	0,8188	0	0	Arah y
Modal	2	0,81	0,8188	0,7503	0	Arah x
Modal	3	0,763	0,8188	0,8031	0	Torsi
Modal	4	0,486	0,8842	0,8031	0	Arah y
Modal	5	0,277	0,8844	0,8399	0	Arah x
Modal	6	0,27	0,8846	0,9018	0	Torsi

Case	Mode	Period *Sec*	UX	UY	UZ	Keterangan
Modal	7	0,262	0,975	0,9018	0	Arah y
Modal	8	0,203	0,975	0,9018	0	Arah x
Modal	9	0,167	0,975	0,9659	0	Torsi
Modal	10	0,157	0,9996	0,9659	0	Arah y
Modal	11	0,156	0,9998	0,9685	0	Arah x
Modal	12	0,135	1	0,9685	0	Torsi
Modal	13	0,13	1	0,9717	0	Arah y
Modal	14	0,102	1	0,9788	0	Arah x
Modal	15	0,101	1	0,9788	0	Torsi
Modal	16	0,099	1	0,9973	0	Arah y
Modal	17	0,096	1	1	0	Arah x
Modal	18	0,083	1	1	0	Torsi

Source : output Etabs 2021 – *show table – analisis result – modal information - modal participacing mass ratio*

Dynamic Earthquake Deviation Control

Dynamic Earthquake Serviceability Limit Performance Control (RXPX, RSPY) Based on

Table 8. Serviceability Limits for Lateral X and Y Deviations

Lantai	Displacement δex (mm)	δeY (mm)	Elastic drift Δsx (mm)	Δsy (mm)	h (mm)	Inerlastic drift Δix (mm)	Δiy (mm)	Drift limit (mm)	cheque
3	26,994	23,158	7,848	7,832	4000	28,776	28,717	46,154	ok
2	19,146	15,326	10,765	9,447	4000	39,472	34,639	46,154	ok
1	8,381	5,879	8,381	5,879	4000	30,730	21,556	46,154	ok

Source : Peneliti 2025

Structural Examination of P-Delta Effects

Table 9. X-direction stability coefficient of design profile

Floor	H (mm)	Δix (mm)	p (KN)	Vix (KN)	Coefficient stability θx	Structural stability limits $\theta xmax$	CHEQUE
3	4000	28,776	4336,7658	529,871	0,0161	0,0909	**Safe**
2	4000	39,472	8169,0491	800,0632	0,0275	0,0909	**Safe**
1	4000	30,730	12001,3323	934,0957	0,0269	0,0909	**Safe**

Source : Peneliti 2025

Table 10. Y-direction stability coefficient of design profile

Floor	H (mm)	Δiy (mm)	p (KN)	Vix (KN)	Coefficient stability θy	Structural stability limits $\theta ymax$	CHEQUE
3	4000	28,717	4336,7658	643,5111	0,0132	0,0909	**Safe**
2	4000	34,639	8169,0491	967,6667	0,0275	0,0909	**Safe**
1	4000	21,556	12001,3323	1107,0729	0,0269	0,0909	**Safe**

Source : Peneliti 2025

From the data in tables 9 and 10, it is known that there is no stability ratio value greater than 0.1. This is in accordance with the rules stipulated in SNI 1726-2019 regarding the P-delta effect.

CONCLUSION AND SUGGESTION

Conclusion

Based on the research conducted, the following conclusions can be drawn: The selected steel profiles for the Sophos School Indonesia Building structure using the SRPMK system are:

1. Main beams: IWF 500×200×10×16 (spans 9.22 m & 8.78 m), IWF 450×200×9×14 (6.00 m), IWF 400×200×8×13 (4.80 m).Sub-beams: IWF 400×200×8×13 (6.00 m), IWF 350×200×7×11 (4.80 m), IWF 300×150×6.5×9 (4.61 m & 4.39 m).Columns: HB 400×400×18×28.
2. Based on the analysis results, it was obtained that the dynamic earthquake base shear force in the X direction was 1238.0 kN and the Y direction was 1407.5 kN, greater than the static earthquake of 1119.7 kN so that it meets SNI 1726–2019 and the building configuration uses a dynamic earthquake (RSPX and RSPY). Mass participation is fulfilled in the 18th mode according to SNI provisions, while the largest inter-floor drift occurs on the 2nd floor of 39.472 mm (X direction) and 34.639 mm (Y direction), still below the maximum limit of 46.154 mm. In addition, the stability ratio value in the P-Delta analysis does not exceed 0.1, so the structure of the 4th floor of the Sophos School Indonesia School Building is declared safe and meets the requirements of SNI 1726–2019.

Suggest

Based on the results of the analysis and discussion that have been carried out, the following suggestions can be given, namely:

1. In this study, researchers should conduct a more in-depth review by calculating the connections used in the steel structure of the Sophos School Indonesia School Building.

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