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Temperature fluctuations and moisture level in external walls. Case study Tirana, Albania

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ABSTRACT: *The incorporation of thermal insulation materials into building walls is a novel strategy for reducing heating and cooling energy consumption. Nowadays, the issues of energy production, consumption, and energy storage have become global problems. Furthermore, the thermal insulation of buildings increases the thermal comfort of residential premises in order to save energy. The use of several kinds of thermal insulation materials is required in the construction sector. This paper compares the thermal and moisture performance of two different types of walls. The buildings taken under consideration are located in two different Tirana'sneighbourhoods, close to each other sharingsimilar climate parameters.*

Depending on the presence of thermal insulation, two types of walls were taken into consideration. Awall in which thermal insulation is not present and a wall with ventilated façade system, are considered. Thermal insulation in the second case is made with rock mineral cotton. In order to obtain the most accurate results, pertinent temperature and humidity, measurements were made at several spots along the walls. The comparative analysis was performed using special measuring instruments. The temperature and moisture level in the internal wallsand the temperatures of the external walls, at various spots on the walls, were taken into consideration, along with the layers of the relevant walls in both cases.

The aim of this paper is to experimentally study the thermal performance of walls with various types of thermal insulation, including the ventilated façade system, as well as walls without thermal insulation. The purpose of the study is also to show how the technical and architectural methods utilized during construction affect the moisture and temperature fluctuations of the perimeter walls.

KEYWORDS:*comfort, thermal insulation, temperature levels, moisture, walls, comparison.*

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I. INTRODUCTION

Buildings require a significant amount of energy in all countries, including Albania in order to be included in the comfort zone. This heating and cooling load can be lowered in a variety of ways, the most significant of which is proper design and selection of the building envelope and its components. The proper use of thermal insulation in buildings not only reduces the required air-conditioning heating and cooling loads, but also the annual energy cost. Furthermore, it aids in extending the periods of thermal comfort without relying on mechanical air-conditioning, particularly during the inter-seasons. The magnitude of energy savings as a result of thermal insulation varies depending on the type of building, the climatic conditions in which the building is located, and the type of insulating material used. Many building owners' minds are now consumed by the question of which type, and how much insulation to use. [1] When a building is well insulated, it isrelatively more energy efficient and less expensive for the consumers to keepthemselves warm in the winter or cool in the summer. Energy efficiency in buildings will result in a lower carbon footprint. When outside temperatures are extremely cold or hot, there is less temperature fluctuation both vertically (between ankle height and head height) and horizontally from exterior walls, ceilings, and windows to interior walls, resulting in a more comfortable occupant environment.

On the other hand, the lack of thermal insulation will result in significant energy losses for the building, (because of the thermal bridges) which also causes economical damage. Heat will always try to find the path of least resistance through a space. Thermal bridges can become a significant source of heat loss, accounting for up to 30% of total losses. This can undermine the work done to insulate a property and contribute to the performance gap between the building's expected and actual energy demand. Additionally, as the inner surface of a construction where a bridge occurs will be cooler than the surrounding area, condensation may form, potentially harming the surface or promoting the growth of mold, causing health problems. [2] These are the reasons why thermal insulation materials have become a key point in the construction industry.

II.THERMAL INSULATION

This article focuses precisely on the exact determination and comparison of the thermal performance of a wall without thermal insulation (building A) and a wall with thermal insulation (building B), taking into account the moisture level and temperature fluctuation at the same point. There was a noticeable temperature loss from the interior to the exterior of the first building due to incomplete thermal insulation. The apartment's exterior walls showed evidence of moisture as well. Whereas the second building was constructed using ventilated façade system, which offers flexibility as an ideal solution to enhance the aesthetics of every type of space, breathability for the facility, high protection for the building envelope,maximizing thermal and acoustic insulation. The ventilated system nowadays is the most functional solution for the protection and energy efficiency of buildings. The thermal insulation material used in this study is rock mineral cotton.

	λ (W/m*K)	ρ (kg/m3)	C (J/kg*K)	Vapour resistivity (MNs/gm)
Rock/stone wool (cavity)	0.037	22	840	5
Rock Mineral wool (external)	0.036	60	1000	5

Table 1-Thermohygric properties of the insulations. [3]

λ (W/m*K) - Thermal Conductivity. Thermal conductivity can be defined as the rate at which heat is transferred by conduction through a unit cross-section area of a material, when a temperature gradient exits perpendicular to the area. [4]
ρ (kg/m3) -The kilogram per cubic metre (symbol: kg·m−3, or kg/m3) is the unit of density in the International System of Units (SI), defined by mass in kilograms divided by volume in cubic metres. [5]
C (J/kg*K)- Specific heat capacity. A material has a heat capacity of 1 J/kg·K if heat energy of one joule is required to raise the temperature of one kilogram of this material by one kelvin. [6]
Vapour resistivity (MNs/gm)- The vapour resistance of a material is a measure of the material's reluctance to let water vapour pass through. The vapour resistance takes into account the material's thickness, so can only be quoted for a particular thickness of material. It is usually measured in MNs/g. [7]
When mineral wool articles are heated, organic compounds are released into the gas phase due to the pyrolysis of the polymer binder beginning at 240°C. There are two temperature ranges of pyrolysis: mostly oxygen-free hydrocarbons are observed in the products below 400°C, and oxygen-containing hydrocarbons, above this temperature, in the case of an oxidizing atmosphere. Mineral wool articles contain more than 5 wt % polymer binder. Aluminosilicate fibres have amorphous structure and crystallize into the augite phase when heated to above 850°C.[8]

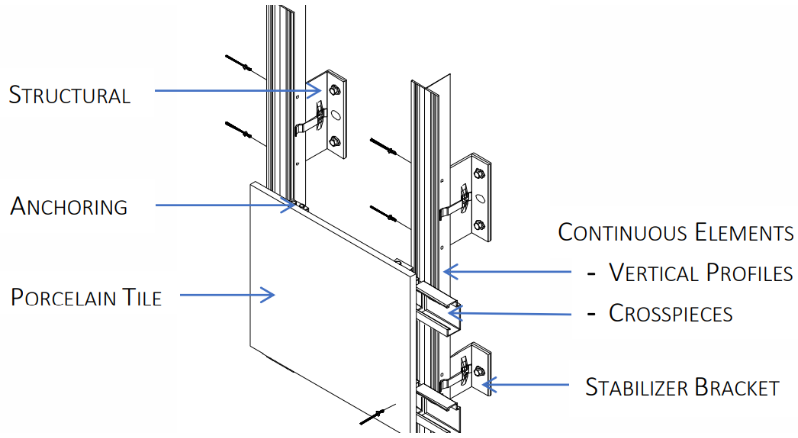
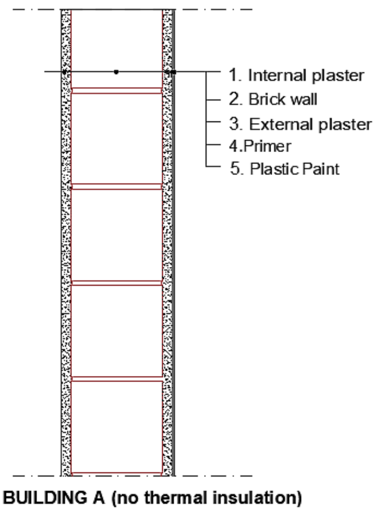


Fig.1 Hidden anchoring system. Source [9]

III. METHODOLOGY

A ventilated façade also provides insulation and regulates humidity, preventing moisture and condensation. The thermal performance of a ventilated façade is primarily affected by the design of its components, such as the distance between the two layers, the exterior cladding material, and the exterior cladding joint typology (open or closed). The lack of software and data to fully assess the thermal performance of a ventilated façade makes evaluation difficult. Nonetheless, for existing buildings, the performance of a ventilated façade can be measured on-site).[10]



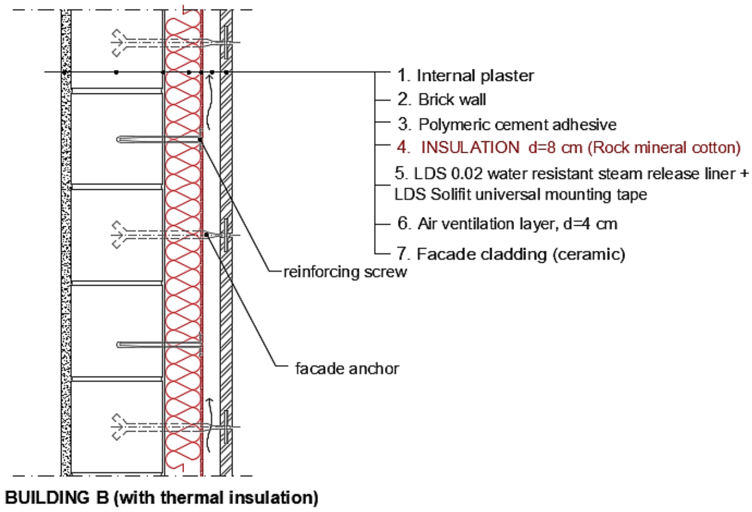


Fig.2 Building A without thermo insulation. Source: Authors

Fig.3 Building B with thermo insulation. Source: Authors

For the measurement of the temperature of the walls was used, the device "MESTEK - INFRARED THERMOMETER", while or the measurement of the moisture level in the external and internal walls, the device "SILVERLINE - Digital Moisture Meter" was used.
In each case, measurements were taken on the 3rd floors at a height of 70 centimetres. The measurements are taken every 50-100 centimetres along the wall's surface on the 27th of December 2022. The buildings are both oriented towards the southwest.

Fig.4
The weather conditions on the 27th of December 2022.
Source: Iphone Weather application

Fig.5
Orientation of the buildings.
Source: Compass Application

Fig.6 MESTEK-INFRARED THERMOMETER.

Fig.7 SILVERLINE - Digital Moisture meter.

The measurements were taken between 13 a.m. and 17 a.m., with temperatures ranging from 11 to 14 degrees Celsius during the measurement period. All of the buildings investigated for this paper were in the vicinity of the "Zogui Zi" neighbourhood, Tirana, Albania. The buildings are located in a distance of 690-meter of one another.

Building A

It is built during 2004 and it has no thermal insulation. The measurements were taken on the third floor, on the external wall with 30 cm width. (as seen in figure 2A)

Building B

It is built during 2015 and it has a ventilated façade system. The measurements were taken on the third floor too (as seen in figure 2B)

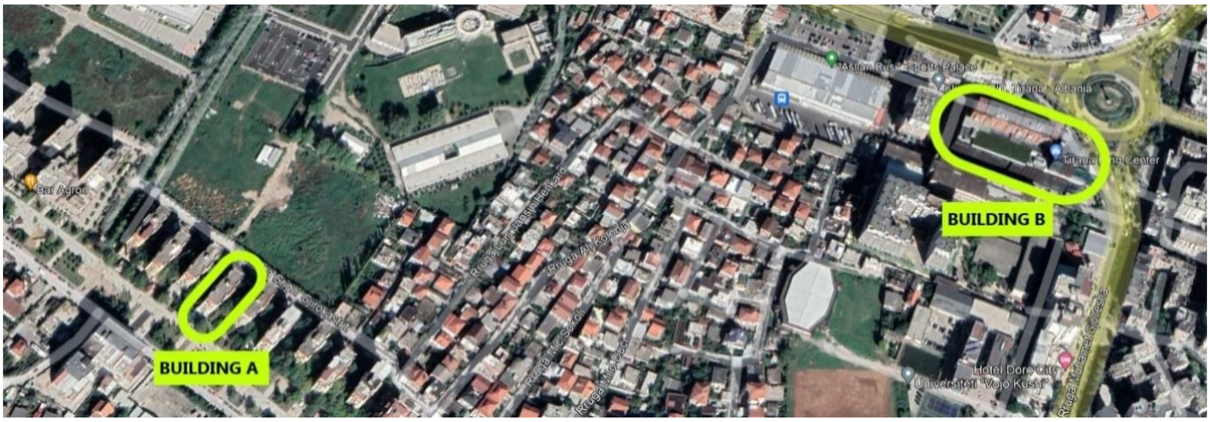


Fig.8Buildingslocation. Source: Google Earth

Fig.9 Building A
Fig.10 Image displaying the building A's outer wall
Source: Authors

Fig.11 Building B
Fig.12 Photo showing the perimeter wall of building B. Source: Authors

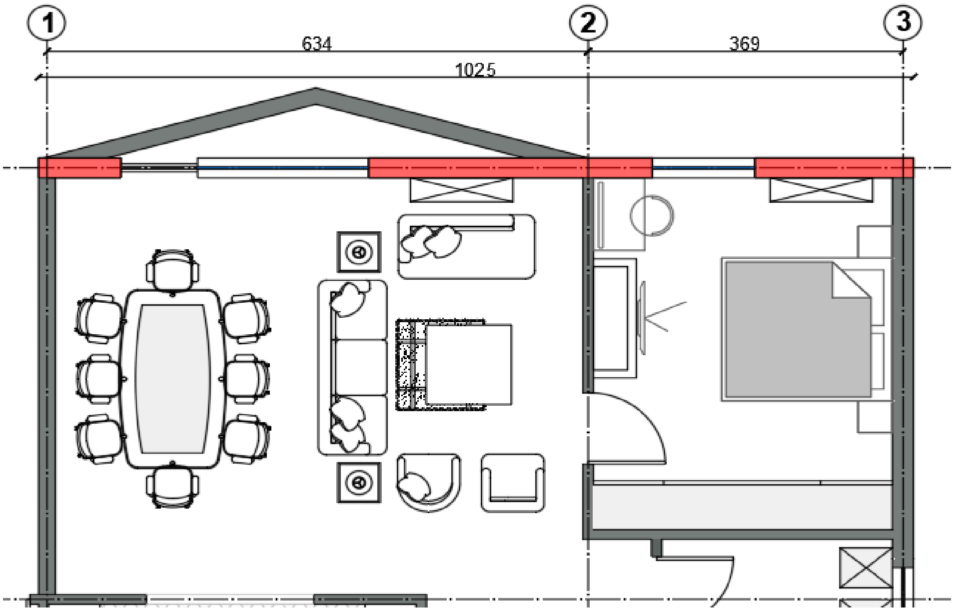


Fig. 13 Floor plan of the apartment (Building A).The measurements were performed on the perimeter wall showed in red. Source: Authors

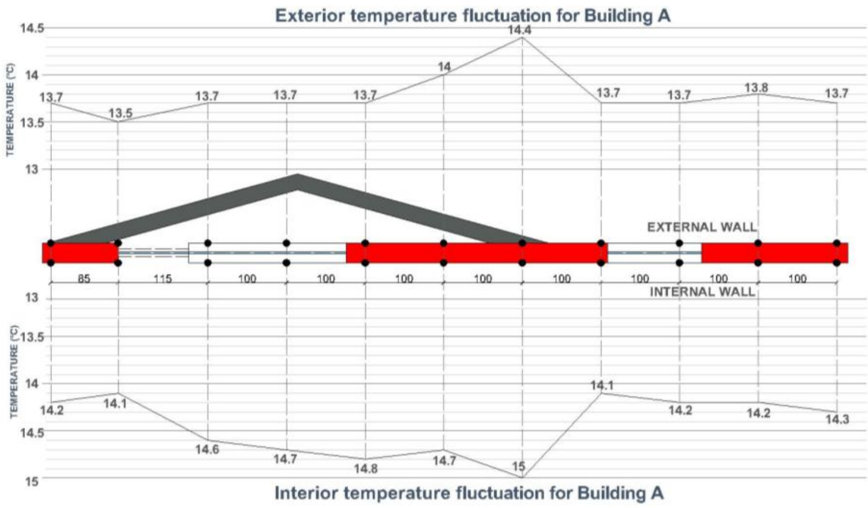


Fig.15 Interior and exterior temperature fluctuation for Building A, Source: Authors

The graph's data show that the external wall temperatures of the building without thermal insulation are nearly equal to the interior temperatures. The difference in temperature ranges from 0.2°C to 1.6 °C. This demonstrates the poor performance of the wall without thermal insulation, indicating that more energy is required to achieve indoor thermal comfort.

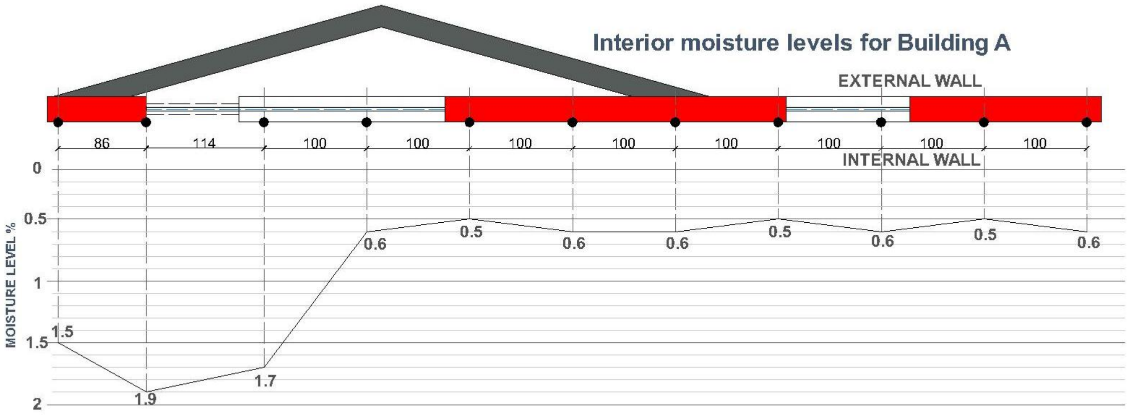


Fig.16 Interior moisture graph for Building A, Source: Authors

The interior of the wall without thermal insulation appears to have excessive moisture in some areas(1.5-1.9%). If too much moisture enters the home, it can lead to a vast array of problems. Excessive moisture in the walls can cause expensive structural damage. In addition, some people may experience respiratory problems as a result of too much moisture.

Fig.17 Visible moisture on the wall, Building A Source: Authors

Fig.18 Corresponding moisture value (%) Source: Authors

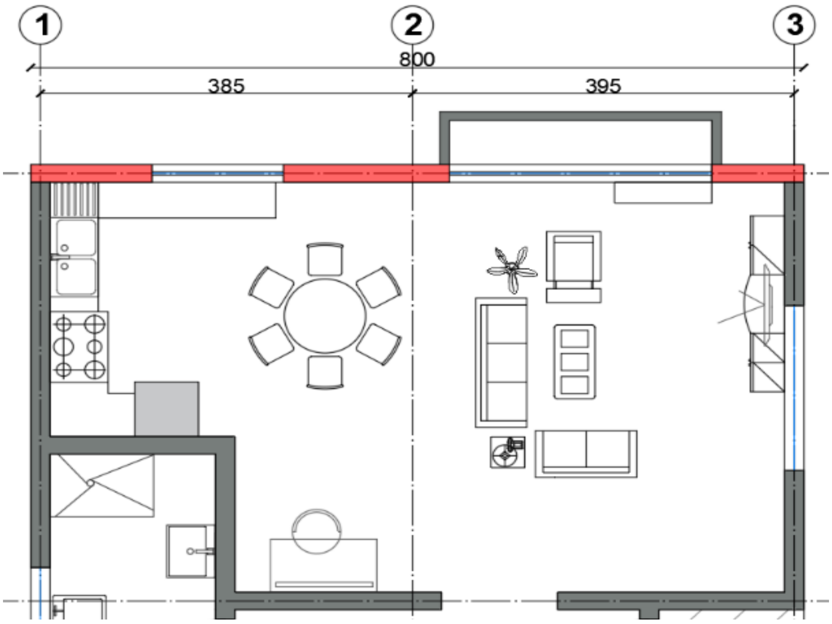


Fig. 14 Floor plan of the apartment (Building B).
The measurements were performed on the perimeter wall showed in red.
Source: Authors

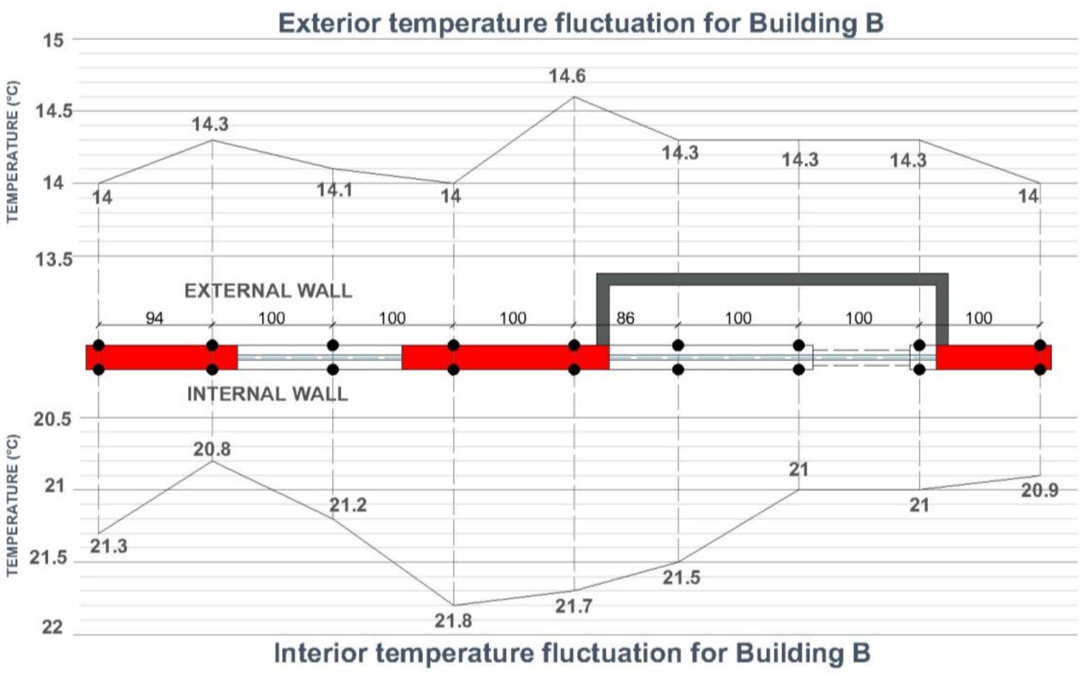


Fig.19 Interior and exterior temperature fluctuation for Building B, Source: Authors

This graph indicates that the temperature difference between the outside and inside of the wall is significant in the building equipped with ventilated façade system. They vary from 6.5°C -7.8°C, indicating a minimum energy or temperature loss in the wall.

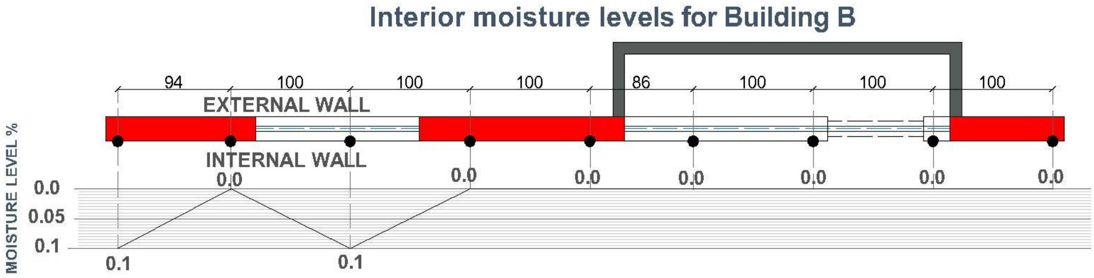


Fig.20 Interior moisture graph for Building B, Source: Authors

The moisture level in the thermally insulated wall is extremely low, ranging between 0%-0.1%. This demonstrates that the ventilated facade system performs admirably in terms of humidity.

Fig.21 and Fig.22 Moisture value on the ventilated façade system, Building B Source: Authors

IV. CONCLUSIONS

The aim of this article was to compare buildings with and without thermal insulation, presenting temperature loss in the walls, moisture fluctuations, and indoor thermal comfort for each category. The accompanying experiments and graphs demonstrate that the ventilated facade system has a high thermal performance, avoiding moisture levels as low as 0-0.1%. These findings indicate that in a system equipped with thermal insulation, less energy is required to obtain thermal comfort, and it is a safer option because the lack of moisture protects both the construction and human health.

On the other hand, the wall without thermal insulation had visible signs of moisture (max 1.9%) and high heat loss, hence a large amount of energy is needed to keep the temperature constant in the interior.

As a result, we must avoid non-thermally insulated buildings. Acting like this, it is conserved energy and strive towards a more ecologically friendly construction world.

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