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## **EVALUATION OF PRICE FLUCTUATION OF DETERMINING MATERIALS FOR TOTAL CONSTRUCTION COST**

### **Abstract:**

The preparation of many investment projects began before the pandemic and is now facing a changed situation that will affect the entire project. One of the significant factors influencing construction projects is the price growth and availability of construction materials. The effects of price changes will take shape during the construction process in the supplier's relations and will affect the project's results from the point of view of suppliers and investors. The effect of rising prices of building materials on the total construction costs for the design of an apartment building is evaluated, and the groups of materials with the largest share of the total cost are identified. Part of the analysis is the assessment of groups of materials with the highest fluctuations in prices for the period, called determined materials. For this group is appraised share in the total construction costs, and the possible effects of price increases on project implementation are discussed.

### **Keywords:**

Total Construction Cost, Construction Material Cost, Price Fluctuation, Construction Material

**JEL Classification:** M11, L74, O22

## 1 Introduction –

Construction costs these days increase dynamically due to many factors. Many construction projects prepared and budgeted during or before COVID -19 pandemic are now under rapid realization and have to face different conditions. The prices of construction materials are changing quickly, and their availability could be limited. The rising costs of construction materials influence the budget and affect investors' expectations. However, the conditions of the contracts with the suppliers could be affected due to prices.

The fluctuation of construction materials prices is dynamic and significant these days. Before the COVID-19 pandemic and war, the situation was more stable, and growth in building material prices was not as notable as at present. Rising construction materials prices are unforeseen for many investors. The current rate of material price growth has significant implications for the entire construction budget.

The total construction price is created by valuing individual items on the list of construction works. These prices are determined using a calculation formula. A very significant part of the total construction price is the material. The article evaluates the impact of fluctuations in the prices of the materials on the final budgeted worth of construction. The aim is to identify and monitor determined groups of materials that form a crucial part of the total construction costs. Based on methodological identification, determine their share in total construction cost. This analysis is performed on a specific representative of the construction product - a residential building.

## 2 Theoretical review

The COVID-19 pandemic had a significant impact on the economy. It has affected many sectors of the economy, such as tourism, industry, services, and agriculture, which resulted in rising unemployment, price volatility, inefficient sources and others. The economic impact of the COVID-19 is now discussed theme, and there exist different works focused on the economic impact of the pandemic.

The reaction of state governments and restrictions affected the economy as well. Jasova and Kaderabkova (2022) discussed and evaluated the impact of government measures on the COVID-19 pandemic. They assessed that the sustainability of the price index in the Czech Republic is very low. Zubikova and Smolak (2022) analysed the macroeconomic impacts of the pandemic in the Czech Republic. They compared the Czech price index with Eurozone countries and found the sectors with higher inflation.

The COVID-19 pandemic impact on the real estate market has been discussed by several authors. Hromada (2021) examined the influence on rental housing in Prague, Czech Republic. D'Lima, Lopez and Pradhan (2022) focused on pricing effects in the U.S. housing market during pandemic restrictions. De Toro, Nocca and Buglione (2021) evaluated the new trend in the residential market in Naples, Italy. They found some structural changes in requirements for residential housing due to pandemics restrictions.

During the pandemic construction industry suffered significant delays (between 4 and 24 months), and almost 90% of the construction projects overran the costs due to restrictions (Ling, Zhang and Yew, 2021). They stated that price fluctuation could be a risk for construction projects due to their long-term characteristics. They admit the construction price considers the availability of resources,

inflation, and other macroeconomic factors. The main factors causing cost overruns determined by Stuchlík (2018) and set that one of the significant factors is inaccurate cost estimates.

Construction costs are a significant part of the design construction project. Stasiak-Betlejewska and Potkány (2015) emphasized the impact of the construction costs on the project's economic efficiency. They discussed the negative effects of cost overruns on a whole construction project. Holcman and Kozel (2020) focused their research on the importance of tracking and managing the costs in the real estate market. They state the necessity of estimating different sorts of costs and total costs of the project. The importance of cost construction estimating accuracy is emphasized by Heralova (2015). Karásek et al. (2018) highlight the importance of the calculation process and the necessity of different factors affecting the total price consideration.

The total construction costs are a sum of an assessed list of works (Brožová et al., 2022). Each item on the list of works is valued by quantity and price per unit. Price per unit consists of direct costs and indirect costs and profit. Direct costs are a sum of direct costs of material, direct wages and equipment operating costs.

The construction industry is a sector with many uncertainties, e.g. inadequate forecasts, which could cause cash flow problems during the realizations (Jiang, Issa and Malek, 2011). One of the factors which could cause inaccuracy is construction material prices (Belay et al., 2021).

These days the whole of Europe faces accelerating growth in consumer prices. Zábajníková (2022) states that in the Czech Republic consumer prices increased year on year by 4.8% in November 2021. In the first quarter of 2022, this growth increased to 7% (ČSÚ, Inflation, Consumer Prices, 2022). Aggregate prices of construction work increased by 7.5% year on year in October 2021, of which prices of materials and products in construction rose by a record 16.8% (Kamenický, 2022).

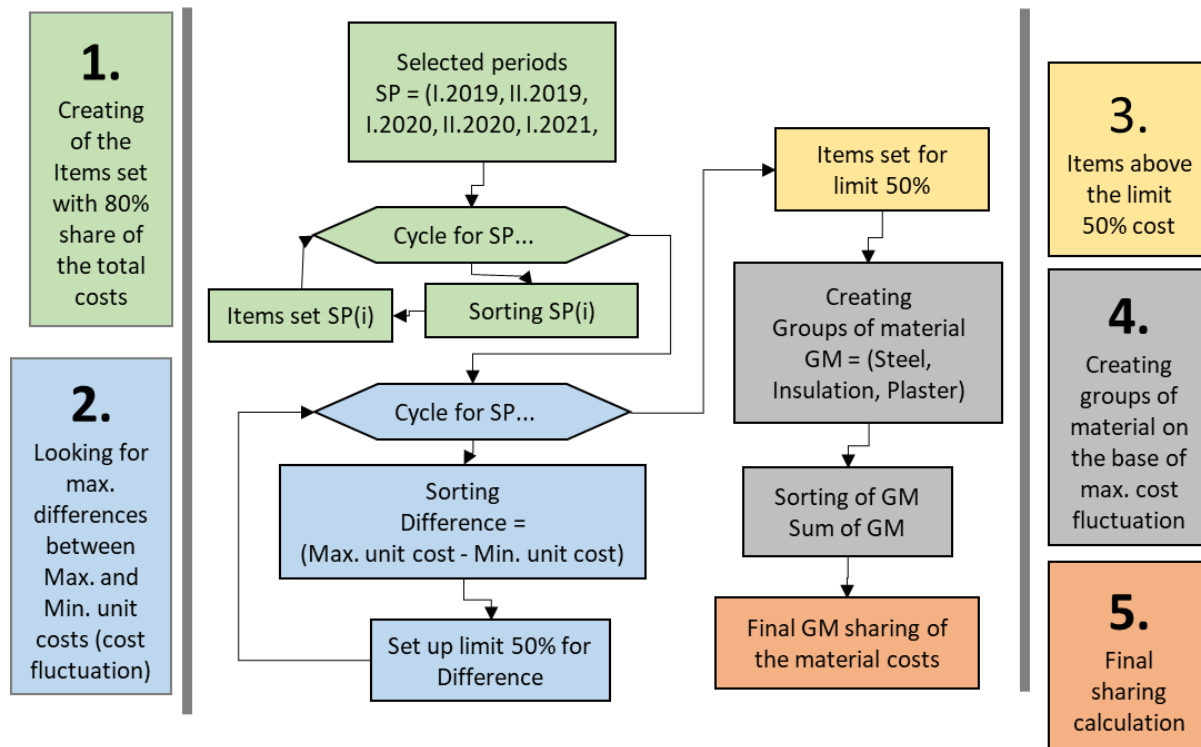
### 3 Methodology

The authors use the budget for a specific apartment building to evaluate the impact of material price fluctuations on the total construction price. This budget is a part of the construction design created within the project solved by the authors for the State Investment Support Fund (SFPI). The total price of the construction has been valued for the price levels of the half years 2019, 2020, 2021 and 2022 using the price databases published by the company URS (URS CZ, no date). The shares of material costs in the total construction price were first determined for the mentioned price levels to evaluate the effect of price growth on the total construction costs.

Then we identified work items with the largest share of the material in the total construction costs for the price level of the year 2022. Some specific works, like HVAC (Heating, Ventilation, and Air Conditioning), measurement and control systems, and air conditioning, we do not consider for the evaluation because these specific works are usually subcontracted.

The total cost of construction costs a group of items that make up a significant part of the total price. Assuming Pareto's rule, this is 20% of the items that make up 80% of the total construction budget.

The total construction price is the sum of the priced items on the list of works. The price of each item depends on quantity and the unit price calculated via the calculation formula. According to the calculation formula, each item includes labour costs (wages), material costs, used machines, energy, overhead and profit. To evaluate the effect of material price fluctuations, we used only materials depending on the amount needed to realize a particular construction. We divided the research into five methodologic steps see Figure 1.



**Figure 1 Flowchart of the methodology steps**

We used the ABC method based on the Pareto's rule to identify the items with the largest share of the total construction price. First, we sorted descending all work items according to material costs and their rate on the total costs. Then we selected the materials with a share of total construction costs together 80%. We worked with half-year periods (I. 2019, II. 2019, I. 2020, II. 2020, I. 2021, II. 2022). Next, we searched max and min differences in price fluctuation in selected periods and set up the limit of 50% fluctuation difference. Then we got the items on the list of materials above the limit of 50% fluctuation. We found the materials on the list of works containing the same materials and assigned them to material items identified in the first step. We created groups of materials (e.g. steel, thermal insulation, joinery) based on maximum cost fluctuation. For these groups of materials, we analysed the progress of prices and the share of total material costs over time. The result shows construction materials with the highest growth and reveals the prices of construction materials which most affected the total construction cost.

#### 4 Analysis and results

For analysis, we used a total cost for a rental apartment house design with 20 apartments and five floors, a brick construction system with monolithic reinforced ceilings (Kalčev et al., 2015). The total construction cost in I.2019 reached 20 097 616 CZK, and in 2022 increased the total construction cost (TC) to 25 868 163 CZK. That means an increase approximately of 30%.

In the text of this part authors use some abbreviations so here is a list of them. TC (Total Cost of Construction), TCM (Total Cost of Material), SGM (Sum of Groups of Materials), TCT (Total Cost

of Transport), GMS – Group of Material – Steel, GMI – Group of Material – Insulation, GMP – Group of material – Plaster.

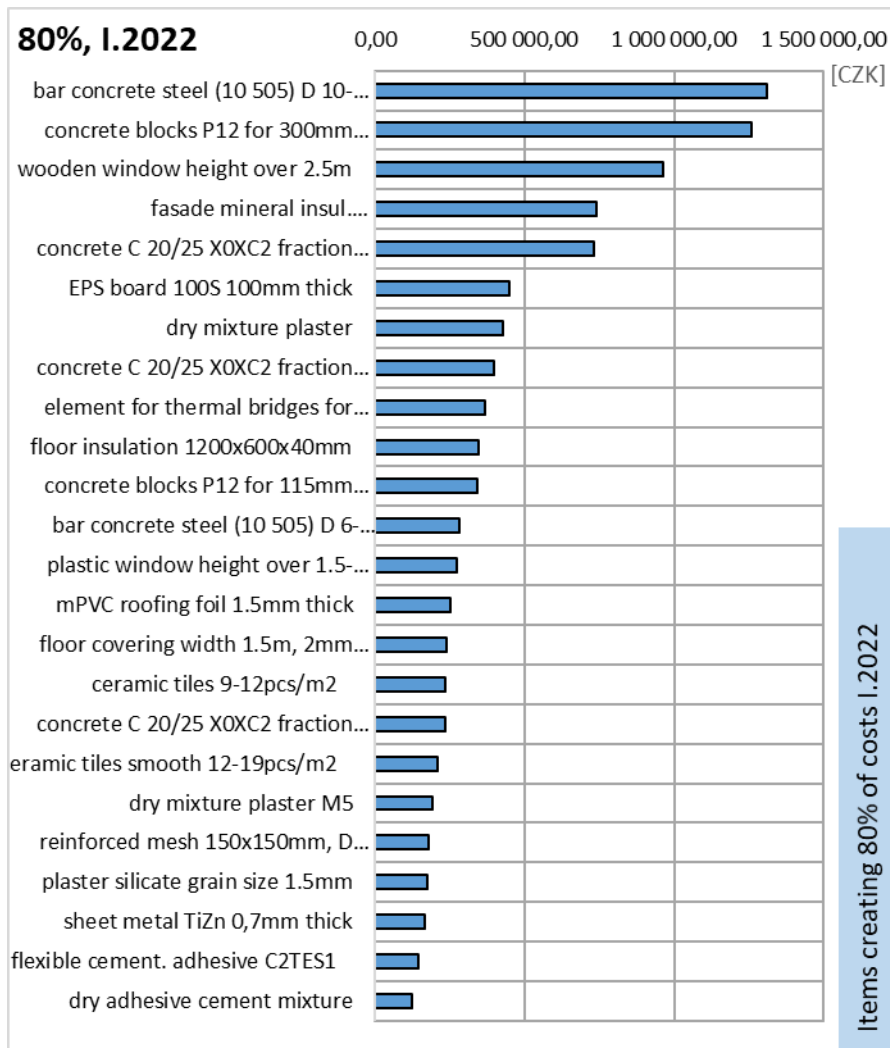
In the text of this part authors use some abbreviations so here is a list of them. TC (Total Cost of Construction), TCM (Total Cost of Material), SGM (Sum of Groups of Materials), TCT (Total Cost of Transport), GMS – Group of Material – Steel, GMI – Group of Material – Insulation, GMP – Group of material – Plaster.

Period		I.19	II.19	I.20	II.20	I.21	II.21	I.22
<b>Total costs</b>	<b>TC</b>	<b>20 097 616</b>	<b>20 900 344</b>	<b>21 115 156</b>	<b>20 425 836</b>	<b>20 843 184</b>	<b>23 425 910</b>	<b>25 868 163</b>
Total costs of material+transport	TCM+TCT	11 145 130	11 713 041	11 757 336	11 437 141	11 305 938	14 624 649	15 055 359
<b>Total costs of material TCM</b>	<b>TCM</b>	<b>10 041 299</b>	<b>10 607 116</b>	<b>10 615 363</b>	<b>10 312 885</b>	<b>10 174 968</b>	<b>13 341 158</b>	<b>13 807 565</b>
Total costs of transport	TCT	1 104 339	1 105 925	1 141 973	1 124 256	1 130 971	1 283 490	1 247 795
<b>Share of TCM on TC</b>		<b>50%</b>	<b>51%</b>	<b>50%</b>	<b>50%</b>	<b>49%</b>	<b>57%</b>	<b>53%</b>

**Tab.1 Share of the total cost of material (TCM) on total construction cost (TC)**

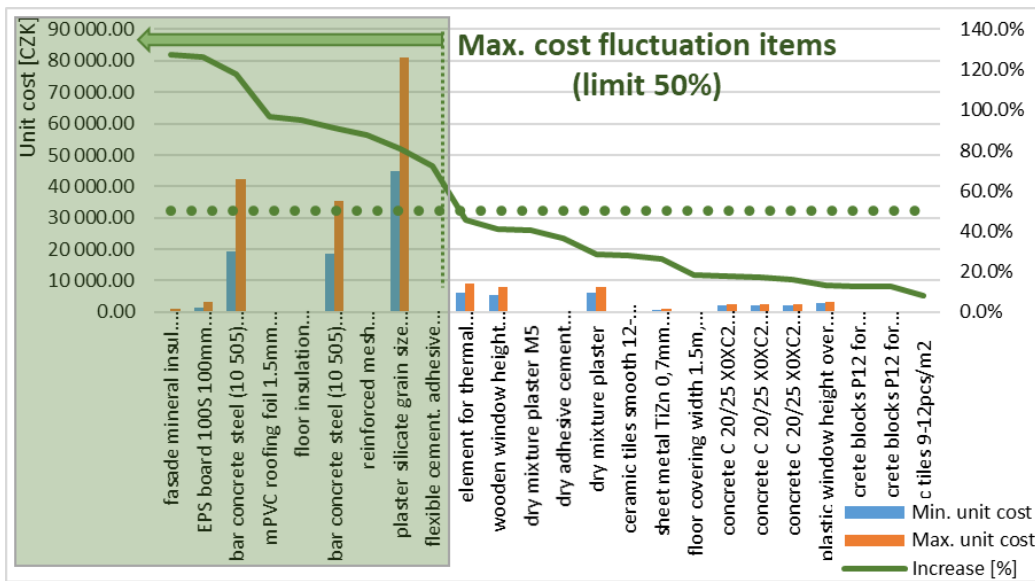
Table 2 also shows transport costs. It is obvious that transport costs fluctuate to a small extent and range from 5 to 5.5% per TC. Given the current growth in fuels and the appearance of the cylinder, it can be assumed that the TCT will grow in the future.

Afterwards, we searched for I.22 materials, which form 80% of the total price of TCM materials. We worked on the assumption that the Pareto's rule is valid. The group of materials that make up 80% of the total cost of material forms 24 items from 197 items which are 12%. The identified group includes materials such as steel, insulation, plaster, concrete and cement.



**Figure 2 Items creating 80% of costs in period I.2022**

In the identified group of materials, we searched for prices for each material for each of the monitored periods. We evaluated the magnitude of price fluctuations and found the materials which had a deviation between the minimum and maximum price greater than 50%. We thus obtained a group of key materials marked in the green field in Figure 3. This group includes, for example, steel, thermal insulation, and plasters.



**Figure 3** Items with max. fluctuations in periods I.2019 to I.2022

In the next step, we only worked with a group of determining materials. First, we assigned the determined materials the same kinds of material from the list of material items. Then these materials were divided into groups, and each group was assigned a code. An example of group names and assigned codes is shown in Table 2.

Groups of materials: Group code	
Steel	130;313
Insulation	ISV;283
Plaster	585

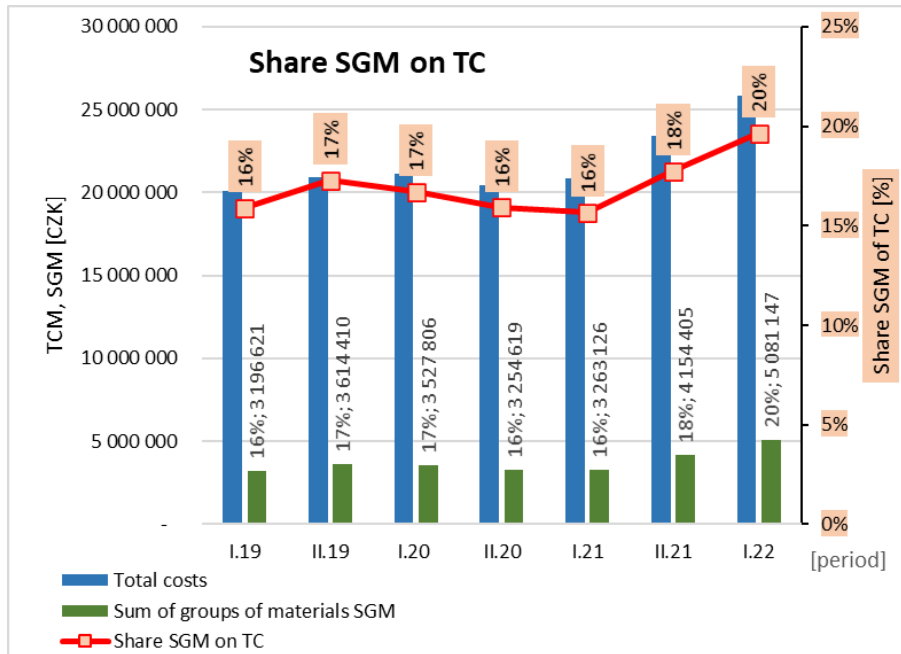
**Tab. 2** Selected groups of materials according to step no. 4 in the methodology

Table 3 shows an overview of determined groups of materials for each monitored period. The development of material costs during periods is represented for each group of determining materials. The highest growth is recorded by the GMS group, which almost doubled its cost growth. In the first monitored period I.2019, the cost of GMS amounted to 942 040 CZK, while in period I.2022, the material cost raised to 1 795 933 CZK, i.e. approx. 91%. For the GMI group, growth is 52%, and for the GMP group, growth is 35% between the first and last monitored period.

Period		I.19	II.19	I.20	II.20	I.21	II.21	I.22
<b>Total costs</b>	<b>TC</b>	<b>20 097 616</b>	<b>20 900 344</b>	<b>21 115 156</b>	<b>20 425 836</b>	<b>20 843 184</b>	<b>23 425 910</b>	<b>25 868 163</b>
Total costs of material+transport	TCM+TCT	11 145 130	11 713 041	11 757 336	11 437 141	11 305 938	14 624 649	15 055 359
<b>Total costs of material</b>	<b>TCM</b>	<b>10 041 299</b>	<b>10 607 116</b>	<b>10 615 363</b>	<b>10 312 885</b>	<b>10 174 968</b>	<b>13 341 158</b>	<b>13 807 565</b>
Total costs of transport	TCT	1 104 339	1 105 925	1 141 973	1 124 256	1 130 971	1 283 490	1 247 795
<b>Groups of materials:</b>								
Steel	GMS	942 040	1 044 432	1 079 467	1 202 935	1 200 180	1 662 426	1 795 933
Insulation	GMI	1 438 417	1 709 677	1 614 257	1 126 348	1 160 319	1 456 829	2 183 259
Plaster	GMP	816 164	860 301	834 082	925 336	902 627	1 035 150	1 101 954
<b>Sum of groups of materials</b>	<b>SGM</b>	<b>3 196 621</b>	<b>3 614 410</b>	<b>3 527 806</b>	<b>3 254 619</b>	<b>3 263 126</b>	<b>4 154 405</b>	<b>5 081 147</b>
<b>Share SGM on TCM</b>		<b>32%</b>	<b>34%</b>	<b>33%</b>	<b>32%</b>	<b>32%</b>	<b>31%</b>	<b>37%</b>
<b>Share SGM on TC</b>		<b>16%</b>	<b>17%</b>	<b>17%</b>	<b>16%</b>	<b>16%</b>	<b>18%</b>	<b>20%</b>

**Tab. 3** Calculation of share SGM of TCM

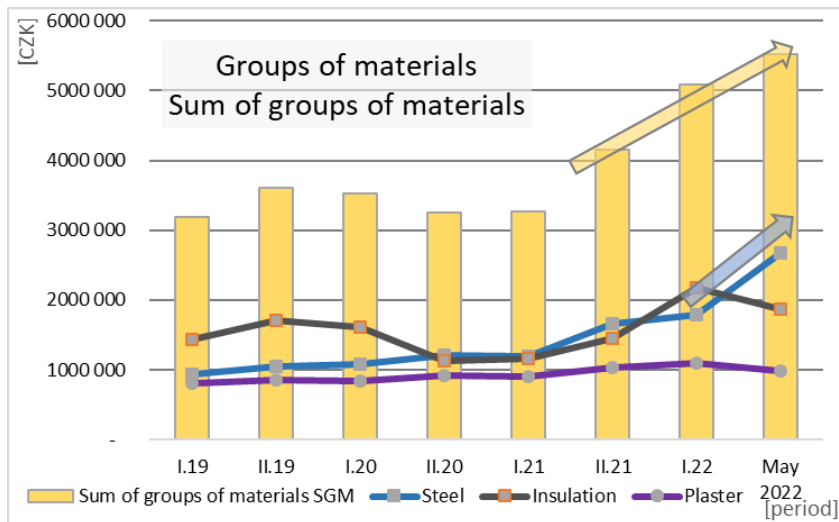
Because of SGM's share of TC, it should be emphasized that the group of determining materials in TC increased to 20% in I.2022. Given the ever-increasing material prices, this share can be expected to increase. One of the reasons may be the uncertainty in the energy market, which affects the producers themselves and thus the availability of materials.



**Figure 4 Share of SGM on TC**

Figure 4 shows the development of TC and SGM and s share of SGM on TC. We can see TC and SGM and their growth in the observed periods. The curve Share of SGM on TC shows the development of SGM's share on TC. There is a noticeable increase in the proportion of determining materials on TC. In most observed areas, the balance of SGM ranged between 16% - 17%, and in the last period, it rose to 20%. This growth will affect construction projects. For subcontractors, rising material prices may have an overall benefit on the contract. For investors, the rise in prices may affect the expected effects of the entire investment. Fluctuations in the cost of transport and a further increase in material prices can also be expected.





**Figure 5 Sum of groups of material and single groups of materials**

Following the graph of the share of SGM on TC is created a chart (Figure 5). This graph shows price fluctuations of individual material groups (Steel, Insulation, Plaster) with the investigated trend in a rise. GMP maintains its level in all monitored periods. However, the SGM (yellow bars in Figure 5) showed growth in recent periods. This rise is due to rising prices at the Insulation Group and especially Steel. Given the current state of production of these commodities, it is unlikely to expect a more favourable development soon.

The graphical representation of the values confirmed the trend of the expected increase in steel prices, which pulls down the growth trend of the TCM. In period I.2022, there is a significant increase in the Insulation group. It is possible to speculate on various causes (supply outages with problematic transport, the impact of subsidy instruments that cause higher demand, etc.).

## 5 Conclusion and discussion

The presented research analyzed the effect of rising material prices on the total construction costs (TCM). The authors found the groups of materials with the highest share in TCM, then searched for materials with high price fluctuations, and evaluated the influence in all monitored periods for each half-years from 2019 to 2022. The share of TCM and total construction cost (TC) for the material groups with the most fluctuating prices have been assessed. The assumption that material prices will gain their share of TC has been confirmed. The growth share of determining materials on TC has a direct impact on the financial results of the entire project. Investors and subcontractors face changes, which have to be reflected in all future project expectations.

Presented analysis processes cost analysis for the specific brick apartment house design. Determining materials include materials like steel, insulation and plaster. However, other materials are used on construction sites as well. Though, these materials were not marked as determining for this project but should be monitored like bricks and wood.

Nowadays, it is necessary to reflect on the development of the international situation when predicting material prices. There is a high level of risk of a shortage of natural gas and a reduction in the iron ore supply. This situation will result in further increases in the prices of steel products and fired ceramic products. These are mainly bricks and roofing, or gas is an irreplaceable energy

source for production in the foreseeable future. These products will show high price increases and become scarce goods.

Another building material with the potential for price volatility and limited availability is wood. Wood prices have risen sharply in the last year. The reason is its lack. This deficiency is caused in the Czech Republic by a bark beetle calamity because infested wood is not suitable for use in construction production. The other problem is the high level of export of this commodity.

Investors and subcontractors should anticipate (consider) possible dynamic developments in material prices during project preparation and, concerning the future development of costs for these sorts of building materials, closely monitor the situation on the market to make more accurate estimates of future costs and consider the risk of a rapid rise in building material prices.

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