

A comparative analysis of selected parameters of roofing used in the Polish construction industry

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Abstract

Roofing is an important element in the construction of the roof. It is also one of the essential elements of the whole building. The choice of roofing should depend on technical parameters that affect the quality of the materials used and the price. The present paper is a comparative analysis of the properties of five roofing materials selected as examples with respect to twelve parameters. As can be seen from the comparative analysis of the roofing parameters, roofing tile is by far the best material, receiving the highest score in the ranking.

Key words: roofing, parameters, comparative analysis

1 Introduction

Roofing is an important element in the construction of the roof. It is also one of the essential elements of the building. When choosing the roofing material, one must take into account all technical parameters that affect the quality of the materials used and the price. Roofing is divided into heavy: ceramic and cement tiles and shingle; and light: sheet, roofing tar and plastics. All kinds of roofing have advantages but also disadvantages.

Each kind of roofing is characterised by different parameters, they differ in appearance and range of application; that is why it is impossible to state which roofing may be considered the best and universal answer to the market demand. In the case of roofing it is important to define the type of object for which the comparison of the analysed parameters is made.

Undoubtedly the choice of roofing is one of the crucial decisions when designing a building. It is important to determine the customers' expectations related to a given roofing type as well as designers' requirements related to particular building solutions and parameters.

Analysis of roofing should include a number of different evaluation criteria, decisive about selection of the roofing type. When building a detached house, one ought to consider both its

aesthetic and technical aspects as well as the cost of a given roofing type. The decorative function loses its prominence in favour of technical and cost parameters in the case of apartment blocks, which is even more evident in the case of industrial buildings. Cost is affected by the weight of the roofing. Heavier roofing generates larger loads which the roof framework must bear. The range of application of roofing is also influenced by the roof angle. Due to all of these factors, the choice of roofing must be considered individually for each of the groups of buildings mentioned above. In the present paper, analysis was conducted for detached houses. It was assumed that all of the assessed parameters have the same weight.

The present paper offers a comparative analysis of the properties of five roofing materials, selected in respect of twelve parameters. Evaluation of the different parameters of each of the materials has been allocated on the basis of the knowledge gained from experts with many years of experience in roofing and on the basis of the literature on the subject (1-14) as well as information from the manufacturers of a given roofing type.

The available books on roof covers most often discuss roof constructions and methods of roof covering (1, 2, 3, 4, 6, 7, 10, 11, 12, 13, 14) but less frequently focus on showing errors and related problems (5) or on presenting customers' opinions and preferences (8). On the market, there are many construction materials with various parameters (11); the choice depends on the investor; however, there is a lack of analyses and comparisons (9), helpful when choosing the best solution.

2 Roofing analysis

Table 1 below presents twelve parameters for five selected types of roofing materials used in the Polish construction industry. The values of the parameters that can be given in a numerical way are given in appropriate units. They were juxtaposed on the basis of available publications and data obtained from experts, roofing producers. Assessment of qualitative parameters, difficult to present numerically, was done using the 10-point scale on the basis of the author's own experience and the opinion of relevant, independent experts (producers, contractors, investors). Appropriate choice of experts is significant as it allows for avoiding subjective judgment. Then, all the parameters were assigned a score from one to five. After summing up the number of scores, the best roofing type was indicated.

What is presented here is a largely simplified, practical and fast method of determination of the best roofing solution, as opposed to the advanced multi-criteria methods applied.

The estimated parameters are discussed below.

PRICE. Roofing price, in many cases, is crucial for its selection. Due to the fact that the roof is the part of the building which is the most vulnerable to the weather factors, one is not supposed to save money on the purchase of materials necessary for its construction, in particular the roofing. Buying cheap roofing exposes one to the fact that one will soon be forced to bear the costs associated with the maintenance, repair and finally with its replacement.

ASSEMBLY. Deciding on a particular type of roofing material, we need to pay attention to both the cost of the roof and the time needed to accomplish this task. Some roofing, such as shingle or tiles (especially plain tiles) require considerable expenditure of time and special skills, which is why the overall cost of roofing tasks, including roof construction, increases significantly. In the case of covering the roof using ceramic tiles, a lot of time is absorbed by trimming the tiles and installation of finishes, especially when we are dealing with a very complicated roof (e.g. dormer windows, eyebrow windows). Depending on the roofing type, laths are placed and/or the roof surface is laid with wooden boards. Generally, a variety of insulating materials (bitumen sheet, insulating foil) are used, which affects the time of roof construction and, of course, the cost.

MAINTENANCE. This term includes: painting, washing, impregnation, moss and rust removal. Moreover, what is taken into account is expenditure on possible replacement of damaged single roofing components, such as roof tiles or shingles.

WEIGHT. Heavy roofing requires an adequately thick roof truss and proper construction, but has the advantage of greater stability on the roof slope and better resistance to the action of wind, which in recent years, considering frequent hurricanes, has been of great importance.

DURABILITY. Different types of roofing materials have different periods of durability. Roofing with short durability generally has a low price but the effect is that, after several decades, it has to be replaced, and this often involves the replacement of the whole wooden structure. The roofing which is fixed to the frame by means of nails or screws, corrodes or rots at fixing points, which reduces its strength.

ACOUSTICS. Acoustics affects the comfort of living, especially in the attic. Roofing materials with appropriate acoustics have the advantage of reducing the noise caused by rainfall and strong winds. As a result of expansion in periods of high or low temperature, certain types of roofing produce characteristic sounds, such as cracking.

FINISH. Finishing tasks include: rooftop finish, soffit and roofing detail installation, installation of roof windows, gutters, chimney flashing. The number and kind of finish depends on whether the roof is complex and varied or simple. In the case of the former, the cost of finish and its installation is significant.

LEAK-TIGHTNESS. Leak-tightness is a basic feature, important for living comfort and durability because it prevents moisture in the roof truss. The higher the leak-tightness of the roofing, the greater the confidence that individual elements will not become detached during strong wind, which could lead to the destruction of the entire roof.

Table 1. Parameters of selected kinds of roofing.

	WOODEN SHINGLE	ASPHALT SHINGLE	GALVANIZED STEEL	SHEET METAL WITH TOPPING	CERAMIC TILE
PRICE PLN/m ²	41	23	22	58	48
Scoring points	3	4	5	1	2
INSTALLATION hrs	3	1,5	2	2,5	2,5
Scoring points	1	5	4	2,5	2,5
INSTALLATION PLN/m ²	70	17	16	28	25
Scoring points	1	4	3	2	3
MAINTENANCE PLN/m ²	22	15	40	12	8
Scoring points	2	3	1	4	5
WEIGHT kg/m ²	8	9	5	7	40
Scoring points	3	2	5	4	1
DURABILITY Years	50	30	35	50	80
Scoring points	3,5	1	2	3,5	5
ACOUSTICS rating	25	60	98	65	35
Scoring points	3	2	5	4	1
FINISH PLN/m ²	8	22	29	35	65
Scoring points	5	4	3	2	1
LEAK-TIGHTNESS rating	5/10	6/10	9/10	8/10	3/10
Scoring points	2	3	5	4	1
VENTILATION rating	5/10	3/10	1/10	2/10	7/10
Scoring points	4	3	1	2	5
AESTHETICS rating	6/10	4/10	2/10	8/10	10/10
Scoring points	3	2	1	4	5
GUARANTEE Years	20	10	15	40	30
Scoring points	3	1	2	5	4
TOTAL SCORE	35,5	34,5	33,5	36	38,5
Classification	3rd place	4th place	5th place	2nd place	1st place

VENTILATION. Leak-tightness should interact with ventilation. Good ventilation of the roof allows for avoiding and minimizing the need for roof renovation. Water vapour must be transferred away from the roof as it poses a threat to the roof structure through the development of mold and mildew. Ventilation ensures proper air circulation.

AESTHETICS. This is also an important issue, which has to be kept in mind when choosing a roofing material. A nice, aesthetic, attractive roof determines the owner's satisfaction and is eye-catching for passers-by. This is possible in so far as it is made of good, reputable, durable material, in a suitable, carefully selected colour and harmonising with the environment in which it is located. In modern times, when the market offers a large selection of kinds, types and sorts of roofing, it is the owner's sense of aesthetics and beauty as well as their financial resources that determines what material will be used to cover the roof of their house.

GUARANTEE. Like any product on the market, roofing products have their warranty periods, during which one can submit complaints about the product.

3. Conclusions from the comparative analysis

Ceramic tile

On the list of parameters of the following, selected kinds of roofing: wooden shingle, asphalt shingle, galvanized steel, metal sheet with topping, ceramic tile, the highest rating was awarded to the ceramic tile.

Already hundreds of years ago tiles were made for roofing, but they were used very rarely, mostly for the roofs of castles, palaces and places of worship. Ceramic tile was a high-class product and there were not many who could afford it. For many years people have searched for roofing material that could be used to replace ceramic tile, but so far nothing similar has been invented.

The only product that in the evaluation of roofing materials ranks higher than ceramic tile is stone slate, but due to its high price it is available for few customers.

Although high, the price of tile reflects its high quality. The product has high technical parameters, it is resistant to atmospheric effects such as rain and temperature and it is non-flammable. It has a porous structure which makes it highly vapour-permeable (a breathable roof), which results in a good microclimate inside the building. Thanks to the ability of large heat accumulation, the outdoor temperature is not transmitted to the interior of the building. Tile takes a very long time to heat up and cool down so that the temperature difference between day and night, summer and winter is perfectly balanced.

An additional positive feature is the high sound insulation that provides users with a quiet interior when it is raining. The raw material used to produce tile is clay so one can call it an ecological product. Roof tiles are coated with precious clays or glazed ensuring proper protective coating and colour, which ensures durability so that the tile is maintenance-free

throughout its period of use. It is heavy and therefore requires a sufficiently strong truss, but its weight has the advantage that the storms and gusty winds will not destroy such roofing as detaching these tiles is very difficult.

If one decides to purchase tiles for their roof, it must be remembered that the price of the tile is less than half the cost of other materials needed to cover the roof because the following elements also have considerable prices: groove tiles, decorative ridge tiles, edge tiles, plain ridge tiles, vents, accessories protecting against snow and aiding mobility on the roof, as well as clips, clamps, brackets, bands and seals.

The durability of this roofing type is estimated at 80 years, and the guarantee is granted for a period of 30 years. Such a long warranty period demonstrates the value and reliability of this product, because no one gives such a long warranty on poor-quality products.

Compared with bituminous roofing or sheet metal, tiles slightly absorb rain, which increases their weight. During their installation, tiles do not become perforated, unlike wooden shingles or sheet metal, which also improves their durability.

Due to the wide range of ceramic tile products (interlocking tiles, fish scale tile, Marseille tile, pantiles, mission style tile), one can use them to cover even the most complex roofs. In Poland, more and more buildings are covered with tiles, which undoubtedly affects the continuing trend to build multi-faceted slopes and overly complex roof shapes.

It can be said that the use of tiles not only provides good conditions for draining precipitation, but also ensures that the building will look aesthetically pleasing and stylish from the distance because this is the greatest of the many advantages of tiles, which in this respect are among the most popular roofing materials.

Sheet metal with topping

In the above comparison, sheet metal with topping received the second place. It is a steel sheet covered with natural mineral topping, protected with acrylic resin mixed with fungicides. The topping protects the metal against mechanical damage as well as moss and algae; it also revives its colour. Toppings also have the advantage of suppressing noise caused by rain in a much better degree than e.g. galvanized sheet.

Its design imitates tiles or shingles. It is produced in a wide range of designs. Furthermore, it does not require the use of a thick truss because it is lightweight.

The unique installation system of this roofing type makes it exceptional. This sheet is very strong, and galvanized coatings protect it from harmful factors in any environment.

The unique installation system, minimal waste, low weight, high quality and durability allow for its use without restrictions.

Undoubtedly, the drawback is that, like any sheet metal, this roofing requires insulation in order to protect the building from excessive heat loss.

Sheet metal with topping is used much less frequently than ceramic tile because its price, the price of roof finishes and the high cost of its installation do not make this roofing type a good alternative to ceramic tile.

Wooden shingle

Wooden shingle coatings are characterized by high durability. They are always in perfect harmony with the environment. They meet high aesthetic requirements. In comparison with e.g. sheet metal and galvanized shingle, they are more resistant to hail, storms, and better than the other roofing types in protecting the building from the heat of sun. Frost does not affect wooden shingles in any way. They are the most environmentally friendly of the listed examples of roofing. If these shingles are cleaved, their manufacture is very time-consuming, which is obviously a large drawback, and which makes their price is very high, but they may have different widths and lengths, and can therefore be adapted to the various requirements of investors. In contrast to the coloured sheet metal or bituminous shingle, wooden shingle is ideal for covering old wooden buildings in the process of their renovation. It looks very good on new buildings with soaring roofs, both wooden and brick or stone ones.

The drawback of wooden shingles is that the new material may have been affected by fungi, mold or insects before its installation and then it quickly begins to deteriorate, which is not found in other types of roofing. Moreover, mosses and algae appear very often in shaded places after a few years if maintenance is inadequate.

Another disadvantage of wooden shingle is that, in contrast e.g. to sheet metal, it is not suitable for flat roofs, as then water has a small slope and flows down slowly, which in turn produces moisture and, consequently, affects durability. In the case of a flat roof, it also requires good ventilation. When we are dealing with a low slope roof, this roofing has to be tripled; and when the slope is greater, the roofing has to be doubled. Undoubtedly, this fact affects the price of the roof because more shingles are needed and their installation lasts much longer, which also adversely affects the overall cost of roofing. Covering the roof with wooden shingle takes the longest of all roofing types and is very labour-intensive. The biggest disadvantage of wooden shingles, which often disqualifies it as compared to other roofing types, is the fact that it is flammable, and fire protection is an additional cost which raises the price of the roof. What is also troublesome is the need to impregnate this roof every few years, but it must be performed so that the shingle lasts 50 years or longer. The warranty is provided by the manufacturer usually for 20 years.

Wooden shingle roofs have, however, the advantage that, when being installed, in principle do not require any type of finish: grooves, corners or ridges, since they are made from the same material as the roof slope. Unlike tile, wooden shingle does not put much weight on the truss because it is very light. Damaged individual components can be easily replaced.

Roofing shingles are expensive, both because of the price of the material and the cost of the roofing installation and maintenance. This is, however, compensated by the fact that they are extremely stylish and environmentally friendly, and also give the owner a sense that the roof is unique in that today few buildings become covered with shingles. This means prestige at a high price.

Asphalt shingle

The main advantage is the price. It is very cheap compared to other roofing materials. It is also very light, so opting for this type of roofing can save the expenses on the roof truss. It can be put on old roofing, such as roofing felt. Its flexibility allows for covering roofs with

rounded, complex shapes and with different slope gradients, and because of the variety of shapes and colours it can make original and unique roofing.

Asphalt shingle is very easy to install; it requires no special skills from the contractor, as opposed to wooden shingle or ceramic tile. As compared with tile, asphalt shingle is very light – the weight of the roofing is 8-11 kg/m², but in comparison with other roofing types (which are laid on laths), due to the fact that it is limp like all kinds of roofing felt, it requires a rigid base, made of chipboard or plywood, the weight of which can be up to 20 kg/m². The use of asphalt shingle makes the cost of finish very small, almost the lowest of all the roofing types listed above as ridge tiles and other finishes are made of pieces of shingles so that there is virtually no waste. In use, the shingle does not require any maintenance operations and the roof cover is leak-tight and does not become deformed under the influence of temperature. Moreover, it is resistant to being detached by wind.

Unfortunately, however, in the shade and under trees it becomes covered with moss and lichen. Undoubtedly, another drawback of asphalt shingle is its short durability. Its low price proves that it will not meet high expectations and requirements of investors because the roofs of this type of material are not very aesthetically pleasing and have an unattractive appearance.

That is why asphalt shingle is not commonly used for the roofing of residential buildings; however, it is often used in small objects, such as arbours, wells, etc.

Galvanized steel

Roofs are commonly covered with galvanized steel sheet with a thickness of 0.5-0.6 mm. It is sold in the form of sheets with dimensions of 1000 mm x 2000 mm, but often the length of the metal sheet is adapted to the length of the roof to be covered.

This sheet does not require a thick truss structure because it is very light but the cost of the wooden structure increases because the sheet is placed not on laths but on the surface which is additionally covered with boards by nailing down boards with a thickness of no less than 25 mm. During the installation of laths and boards it should be noted that the nail heads must be driven deeply into the wood so as not to come into contact with the steel and not to cause corrosion. It is advisable to use galvanized nails.

Galvanized steel is steel sheet coated with multilayer coatings protecting it against mechanical damage and corrosion. It is produced as flat, corrugated or trapezoidal sheets. In terms of the number of roofs covered, it has gained the second place after the ceramic tile; however, there is a very big difference between these two types of roofing. The very low price indicates that the quality of this roofing material leaves much to be desired. This sheet is not suitable for complicated roofs because there is a lot of waste.

Roofs covered with sheet metal are tight, but they have very poor ventilation. They require the use of good insulation. In contrast to the ceramic tile, galvanized steel heats up quickly and cools down quickly, and when it is raining and windy it does not suppress the noise but even enhances it. Another disadvantage is that it is highly susceptible to corrosion, and during the assembly it becomes punctured, which significantly weakens it and reduces its durability. Producers give it a short warranty period, in contrast to e.g. sheet metal with topping and even

to wooden shingles. During snowy winters, one must be careful of piles of snow left on the roof slopes and rapidly sliding down.

Galvanized steel sheet can be used on all types of roofs, regardless of the angle of inclination. In highly industrialized regions, with high air pollution and sulfur dioxide or in coastal areas (with high salinity), its durability will be greatly reduced.

Grooved and ridge tiles are made of the same material which covers the entire roof slope, i.e. flat metal sheet, which in the case of trapezoidal or corrugated sheet looks unaesthetic and affects the overall image of the roof.

Because galvanized steel is produced in a large variety of colours, there are roofs in yellow, green or blue, which contrasts with the buildings with other roofing types and adversely affects the landscape, as it disturbs its harmony.

4. Conclusion

In this day and age, when aesthetics, durability and ecology are the most important, the roofs of newly constructed buildings as well as renovated ones, where the roofing becomes replaced, are increasingly covered with ceramic tile. Tile as a roofing material has been known for a very long time, but was rarely used, and due to its price it covered churches, palaces and mansions.

As can be seen from the comparative analysis of the parameters of selected roofing types, tile is by far the best roofing material; it has received the highest rating; it enjoys the highest approval among investors and customers.

Tile has successfully replaced shingle because it can be used to make roofing for the most complicated structure; moreover, it is very well suited to wooden buildings.

It should be noted that tile is also a rewarding kind of material for a roofer as the effort which he certainly puts into covering a given roof becomes compensated by the final effect, which is its elegance.

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