Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 84, 2013: 170-175
(Ann. WULS - SGGW, For. and Wood Technol. 84, 2013)

Wooden shingles in modern construction industry

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Abstract: *Wooden shingles in modern construction industry.* Wood roofing products are almost the oldest construction solutions used in the construction industry. Nowadays they are often replaced in urban environment by newer materials such as ceramic or cement-based tiles, sheet metal and roofing felt. However, they still are used in rural or rural-style buildings. Regulations concerning the construction of residential and public utility buildings require that construction products (including shingles) have documented properties. This paper suggests possible requirements for wooden shingles manufactured and used in modern construction industry .

Keywords: wooden shingles, roofing, roofs, technical approvals, product approvals.

INTRODUCTION

Wooden shingles are probably the oldest natural roofing material. We may still find buildings with such roofing installed even dozens years ago. Basically, until recently, this type of product was used almost only in rural buildings (decreasingly) or in historical constructions. Complex cultural and sociological factors (including the undeniable increase environmental awareness) contributed to rapid growth in interest in traditional materials and technologies. Shingles and shingle-roofs are part of this trend.

However, construction products present on the market (including wooden shingles) require, before installation, proper certification of suitability for use in the target area - these matters are governed by the Construction Law, Regulations of the Minister of Infrastructure, EU Directives (e.g. 89/116/EEC). Legal requirements are created to ensure that materials and products introduced into the market are safe and suitable in their use.

As stated above, shingles used in modern construction industry (although they are known and used for centuries), require a declaration of compliance with Technical Approval, or, where appropriate, a declaration of compliance with the requirements of rather complicated specific authorization procedures or requirements for rural products.

Durability and functionality of the roofing is significantly affected by the type and quality of the used material, technique and accuracy of its installation. The observance of technical recommendations is an essential requirement for all construction works, but the individual features of used products help to maintain the longest operational lifetime.

This paper presents methods and requirements developed for an objective technical evaluation of wooden shingles (split or split-cut) in order to form theoretical basis of national technical approval.

EXPERIMENTS

Experiments were performed in a laboratory on a model of the roofing with dimensions of 2500x3500mm. A structure - rafters, spaced 0.75 m with attached wooden lathes (40x50 mm, spaced at 0.18 m) – was covered by two layers of nailed shingles made of aspen (*Populus tremula*) with a balanced water content (after drying in natural conditions): length of 400 mm and a width varying from 70 mm to 100 mm. Shingles were fixed with galvanized nails with a length of 70 mm. The thickness of the shingles varied, depending on the place of measurement. The

thickest measured point was 20 mm, while the thinnest (at tongue) 3 mm. In order to make the model (hereinafter as the sample) only aspen shingles were used and they met the requirements specified in Table No. 1. The requirements listed in Table 1, are based on historical solutions, analysis of available literature, technical evaluation of existing roofing materials - mainly in sacral or historical buildings – and DIN standards concerning the wooden covering made of "lathes".

The sample was subject to the following treatment:

- conditioning (approx. 5 weeks) at a temperature of approx. 18 °C and in relative humidity of 55-70%, until achieving balanced water content;

- the sample was mounted on a test bench with adjustable tilt angle (four different tilt angles were used during the test in relation to the reference level);

- irrigation - watering the surface of the sample with water at a temp. of approx. 18 °C for 4 hours and in the amount of 5 l/min/m^2, observing the behaviour of the roofing during and immediately after irrigation, i.e. flatness, colour changes, any leaks or capillary rise;

- conditioning in laboratory conditions, as above. (approx. 5 weeks);

- impact resistance test with a hard object (1 kg, impact energy of 5 J) and soft object (50 kg, impact energy 2000J), performed on the sample positioned on a flat surface.

Results of the irrigation test (observation during and after the irrigation) and resistance to impact with a hard and soft object are included in the criteria for assessing the suitability of the solution in terms of safety and convenience. This paper does not deal with issues related to fire safety. The roof made of aspen shingles is classified as B_{roof} (t1) (acc. to DIN EN13501-5 + A1: 2010 Method 1) – a fire-retardant roof , according to Regulation the Minister of Infrastructure of 12 April 2002 (Journal of Laws No. 75 of 15 June 2002, item 690, as amended).

Quality criteria for shingles are presented in Table 1, test results of the model are presented in Table 2.

Table 1. Quality criteria for split and split-cut shingles

No.	Assessed feature	Wood species				
		Oak (Qurcus spp.),	**Larch** (Larix spp.),	**Pine** (Pinus sylvestris),	**Fir** (Abies alba)	**Aspen** (Populus tremula).
1	*2*	*3*	*4*	*5*	*6*	*7*
1	Colour	Variations in colour due to the natural properties of wood are acceptable.				
2	Sap-wood	Unacceptable				-
3	Knots	In the covered part of the shingle, at approx.40% from the upper edge, knots are allowed when their size is up to 10 mm in diameter and they are permanently fused with wood.. Holes left by knots, damaged knots, knots with bark pockets - are not accepted. None of the above faults is accepted on exposed surfaces.				
4	Resin pockets	-	Allowable in the upper, covered part of shingles (i.e. 40% of length from the upper surface),			-

No.	Assessed feature	Wood species				
		Oak (Qurcus spp.),	**Larch** (Larix spp.),	**Pine** (Pinus sylvestris),	**Fir** (Abies alba)	**Aspen** (Populus tremula).
1	*2*	*3*	*4*	*5*	*6*	*7*
			shallow and not penetrating the surface			
5	Bark pockets	Unacceptable				
6	Insect traces	Unacceptable				
7	Frontal cracks	Unacceptable				
8	Surface cracks	Acceptable: shallow, not penetrating the whole thickness, not affecting leak tightness				
9	Ring inclination	At the cross-section -the slope of grain from 30 to 90°; On the surface - grain parallel to the side edge of the shingle				
10	Slope of grain	Layout of grain parallel to the side edge of the shingle, the allowable deviation of 2% of the sum of shingle length and width, but not more than 10% of the items in one package				
11	Number of growth rings	Min. 4 ring per 1 cm. *(Measurement perpendicular to the growth direction)*				Hard to define
12	Dimension tolerance Width: Length: Thickness:	 Width: minimum 80 mm, maximum 120 mm; width, average in a package 100 mm, allowable deviation from +25mm to -6mm; Length: allowable length deviation from -10 mm to +30 mm, whereas 10 % of the delivery may length differing up to - 6% of length In broader, middle part, thickness 20 mm; thinner side at the tongue and "wings" of the groove min 3 mm thickness; minimum thickness at local broken grain sections: 3 mm.				
13	Edge parallelism	Allowable deviation – up to 2 mm				
14	Warp	Up to 2 % of the sum of width and length; not more than 10 % of elements in the package				
15	Rectangularity (angle at the bottom edge)	Perpendicular edges- permissible deviation of the lower edge from the right angle – up to 2 mm, irrespective of the width of the shingle				
16	Flatness	Flat elements, permissible deviation from flatness is not more than 5 mm and not more than 10% of the items in the package.				
17	Curvature-longitudinal sides-transverse planes	Permissible deviation - not more than 4% of the sum of length and width				
18	Groove / tongue shape	minimum tongue thickness 3 mm, minimum width of each edge of groove 3 mm				
19	Content of a package (bundle)	Shingles of the same shape, length, thickness and width to provide 1 linear meter of covered roof. Shingles packed after conditioning with spacers. Permissible deviation –up to 5 %.				

Table 2. Results of leak-proof and impact tests

No.	Roof surface inclination, degrees	leak-proofness of the roofing	Impact test result	
			with hard object	with soft object
1	*2*	*3*	*4*	*5*
1	71 °	+	Not tested	
2	54 °	+		
3	45 °	+		
4	22.5 °	+		
5	20 °	-		
6	0 °	Not tested	+	+
+ no leaks through the roofing, no penetration through the roofing - leak(s) through the roofing, penetration(s) through the roofing				

RESULTS

Selection of required parameters for shingles was chosen basing on obtained data and taking into account the issues mentioned above. Leak-proof and impact tests were performed to confirm the correct selection of parameters and installation methods. Moreover, impact tests are mandatory when assessing safety of roofs and skylights.

After analysing the test results, we may state that selected shingle parameters were adequate. The roofing proved to be leak-proof, providing an effective protection against rain, within the specified limits, and protecting the structure against percolation (no seepage observed on the back side of shingles). The roofing subject to impact of hard objects (simulated hail), did not reveal any damage (apart from few, insignificant dents) that may affect the durability of the roofing. The roofing subject to impact of soft objects (simulating the impact human body) also maintains its integrity – it did not reveal any damage reducing its durability or operational safety.

The roof covered with shingles changes colour during irrigation – it darkens and after drying in ambient conditions (without rain) its colour becomes lighter and in some spots it may become grey/bluish. Observation of roofs in natural conditions indicates that this grey/bluish colour disappears under intense solar radiation.

After analysing the results shown in Tables 1 and 2, we may state that:

- The research analysed the feasibility of roofing made of wooden shingles (split) that meet the requirements of current regulations.
- Sample – a roof model covered with two layers of aspen shingles meeting the requirements presented in Table 1, fixed directly to the roof structure without the waterproofing layer, tested at angles of 22.5^{o} to 71° of roof surface inclination, proved its leak-proof properties – as no leaks or percolation was observed at all test angles. The model in the specified range of roof surface inclination is leak-proof during irrigation. The sample tested at angles lower than 22.5^{o} indicates a “backflow” phenomenon towards back surface of the shingles. Moreover, during conditioning it was observed that “breathing” of sample surface depends on the angle of its inclination.

- The model placed in flat position, after obtaining balanced water content and subject to hard object impact (10x) was not damaged. A few, shallow dents do not impact tightness and durability of the roofing.
- The model placed in flat position, after obtaining balanced water content and subject to soft object impact (1x) was not damaged. The roofing surface maintained its integrity, there was no damage to the surface of the shingles or the roof structure; the roofing met the requirements for operational safety.
- Aesthetical features of the roofing in terms of maintaining flat surface were assessed positively.

CONCLUSION

- The roofing made of two layers of aspen shingles were tested on a test bench with adjustable inclination in the following range: 22.5, 45, 54 and 71°; it was subject to laboratory irrigation and revealed no leakage after a few hours of water exposure, proving its suitability as water protection material. It is possible to construct roofing surfaces made of split shingles fixed to the structure at the specified inclination angles.
- The colour of the roofing changes subject to irrigation due to the saturation of wood, but any bluish/grey traces subside after a period of intense sunlight exposure.
- The roofing model after the irrigation period behaves satisfactory – there are no significant flatness defects or mechanical damage of shingles.
- The fixing method and roof inclination angle influence roof tightness and thus its durability.
- The roofing made of two layers of aspen split shingles, subject to irrigation and impact tests did not reveal any damages. The roofing was not penetrated or damaged – only hard object hitting the roof left shallow insignificant dents not affecting roof tightness or durability.
- The roofing made of two layers of aspen split shingles, subject to irrigation and impact tests (after conditioning in ambient conditions +18°C and 60% HR to achieve balanced water content), maintained its integrity ensuring that the requirements of operational safety are met,
- The roofing made of two layers of aspen split shingles – constructed in a manner described above, meet binding regulations for safety and suitability defined for modern roofing products and techniques.

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Streszczenie: *Dachówki drewniane we współczesnym budownictwie.* Drewniane dachówki są jednym z najstarszych rozwiązań stosowanych w budownictwie. Współcześnie, w środowisku miejskim są zastępowane przez pokrycia ceramiczne, blachę albo inne nowoczesne materiały. W budownictwie wiejskim albo stylizowanym na wiejskie są jednak do dzisiaj używane. Zasady dotyczące konstrukcji budynków wykończonych takimi pokryciami mają swoje regulacje prawne. Praca sugeruje wymagania które mogłyby byćstawiane dachówkom drewnianym produkowanym współcześnie i wykorzystywanym we współczesnym budownictwie.

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