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(54) Title: PANEL AND METHOD OF PRODUCING A PANEL

(57) Abstract: A panel is formed from rice straw compressed with a phenolic resin under conditions of elevated temperature and pressure to thereby press or extrude the panel. The panel disclosed is relatively light weight, mechanically strong, resistant to moisture, vermin attack and damage and has a low level of flammability. The panel may be suitable as a building and construction material for walls, floors, ceilings, tiles, architraves, mouldings and/or cornices associated with structures such as houses, sheds, garages, factories, commercial buildings and/or fences, although without limitation thereto.



TITLE

PANEL AND METHOD OF PRODUCING A PANEL

TECHNICAL FIELD

THIS INVENTION relates to a panel, such as a building panel. More particularly, this
5 invention relates to a panel comprising rice straw bonded by a phenolic resin and a
method for producing same.

BACKGROUND

Rice as a food source is the second largest crop grown around the world with
annual production of approximately 471 million metric tonnes according to the USDA.
10 For each tonne of grain harvested there is approximately the same amount of residual
material left behind in the field and has to be removed prior to planting the next crop.
One of the most common methods of removal is by burning the residual material,
however this process progressively becoming unacceptable in many countries due to the
effect on atmospheric pollution. Where rice growers seek to incorporate rice residues
15 into the soil there is the potential of causing methane emissions that contribute to
climate change.

The consequence of reduced or eliminated burning of rice straw is that large
amounts of the waste material needs to be applied to other uses. The other end uses
include bedding and fodder for animals such as pigs, cattle or poultry and to a lesser
20 extent biofuel production.

SUMMARY

The invention is directed to a new and economically valuable use of rice straw in
a panel which may be used in a variety of applications in building and construction.

A first aspect of the invention provides a panel comprising compressed rice
25 straw bonded with a phenolic resin.

A second aspect of the invention provides a method of producing a panel, said
method including the step of compressing rice straw bonded with a phenolic resin to
thereby produce the panel.

A third aspect of the invention provides a panel produced by the method of the
30 second aspect.

A fourth aspect of the invention provides a structure comprising the building
panel of the first or third aspects or produced according to the method of the second
aspect.

Suitably, the rice straw is bonded with the phenolic resin at about 2-20%, 5-15% or preferably about 10% by dry weight. Typically, bonding occurs for sufficient time and at a suitable elevated temperature and pressure to ensure or facilitate completion of the bonding reaction.

5 In one embodiment, compression is performed by a forming press. Suitably, the forming press comprises one or more heating elements to provide an elevated temperature suitable for bonding the rice straw and the phenolic resin.

 In another embodiment, compression is achieved by extrusion. In one particular embodiment, extrusion is by a screw press-equipped block press with an appropriately
10 shaped extruding die for the profile required.

 Unless the context requires otherwise, the terms “*comprise*”, “*comprises*” and “*comprising*”, or similar terms are intended to mean a non-exclusive inclusion, such that a recited list of elements or features does not include those stated or listed elements solely, but may include other elements or features that are not listed or stated.

15 The indefinite articles ‘*a*’ and ‘*an*’ are used here to refer to or encompass singular or plural elements or features and should not be taken as meaning or defining “one” or a “single” element or feature.

DETAILED DESCRIPTION

20 The invention provides a panel that comprises a rice straw, a by-product of rice-growing. The rice straw is compressed with a phenolic resin under conditions of elevated temperature and pressure to thereby press or extrude a panel formed of the cured, bonded rice straw. The panel disclosed herein is relatively light weight, mechanically strong, resistant to moisture, vermin attack and damage and has a low
25 level of flammability. The panel disclosed herein may also provide significant environmental benefits by utilizing rice straw that would be burned or otherwise wasted or discarded. The panel may be suitable as a building and construction material for walls, floors, ceilings, tiles, architraves, mouldings and/or cornices associated with structures such as houses, sheds, garages, factories, commercial buildings and/or fences,
30 although without limitation thereto.

 In one aspect, the invention provides a panel comprising compressed rice straw bonded with a phenolic resin.

In another aspect, the invention provides a method of producing a panel, said method including the step of compressing rice straw bonded with a phenolic resin to thereby produce the panel.

Yet another aspect of the invention provides a panel produced by the method of
5 the aforementioned aspect.

A further aspect of the invention provides a structure comprising the panel disclosed herein.

It will be appreciated that the panel disclosed herein comprises rice straw bonded with a phenolic resin.

10 As generally used herein “rice straw” refers to any vegetative part or portion of a rice plant, inclusive of stems, leaves, leaf shoots, husks or any other part or portion of the plant that is not a rice grain. Typically, the vegetative part or portion of the rice plant is at least partly dehydrated or has reduced moisture content relative to the starting vegetative plant material. Suitably, the rice plant is of the genus *Oryza*, preferably of the
15 species *Oryza sativa* inclusive of all varieties and cultivars such as the *japonica* and *indica* varieties.

Suitably, the rice straw is obtained after rice grain harvesting. Rice fields are selected for the straw to be utilised for panel production based on an absence of significant weed contamination and/or uniformity of the field surface to thereby reduce
20 soil contamination of the harvested rice straw.

Typically, rice plants are mown or otherwise cut to reduce rice plant moisture levels to less than 12% for harvest. Preferably, rice straw harvesting is performed using a precision chop forage harvester that cuts the rice straw into lengths of about 5-20 mm or preferably about 10-12 mm. However, it will be appreciated that the preferred lengths
25 of about 10-12 mm can be achieved by any harvesting procedure known in the art.

Suitably, the harvested rice straw is stored loosely under aerated conditions to further reduce moisture levels to about 1-12%, 3-10 % or preferably 6-8% on a dry weight basis. Storage may be for between 1 day and about 12 months.

Suitably, the harvested rice straw is further reduced in size to no more than
30 about 6-8mm in length. This may be achieved, for example, by hammering the rice straw through a suitably sized orifice. The rice straw is then passed through a sieve or filter (*e.g.* a “Cyclone” type machine) to remove dust and very fine particles.

The rice straw is then mixed with bonding resin. A suitable ratio of rice straw to bonding resin is about 2-20%, 5-15% or preferably about 10% by dry weight.

Suitably, the bonding resin is a phenolic resin. A non-limiting example of a phenolic resin is a phenolic formaldehyde resin.

Typically, bonding occurs for sufficient time and at a suitable elevated temperature and pressure to ensure or facilitate the bonding reaction and curing of the rice straw/resin composite.

In one broad embodiment, the rice straw is compressed during bonding to thereby produce a “flat” panel. In this context “flat” means having substantially planar surfaces. In a non-limiting example, such panels are typically 1200mm x 2400mm in size.

In a preferred form of this embodiment, compression is performed by a forming press. Suitably, the forming press comprises one or more heating elements to provide an elevated temperature suitable for bonding the rice straw and the phenolic resin. A preferred elevated temperature is in the range 150-250°C, 180-220°C or more preferably 200°C. The forming press may be fitted with pre-heated mandrels at a temperature such as described above and the rice straw and bonding resin pressed for a period of about 3-12 minutes, 5-10 minutes or preferably 7-8 minutes to allow the elevated temperature and pressure to facilitate the bonding reaction and curing of the rice straw/resin composite. In some embodiments, heating may be delivered by heated oil flow through the mandrels.

In another embodiment, compression is achieved by extrusion. Extruded panels may be suitable for use as tiles or specialty shapes for applications such as skirting boards or architraves. In one particular embodiment, extrusion is by a screw press-equipped block press with an appropriately shaped extruding die for the profile required. Heating may be delivered by heated oil flow through the extrusion chamber of the extrusion tool. The temperature is preferably between about 200 to 250°C.

The panel disclosed herein is relatively light weight, mechanically strong, resistant to moisture, vermin attack and damage and has a low level of flammability. The panel can be in any pressed or extruded form that can have a variety of applications in building and construction such as wall panels, ceilings, roofing, doors, tiles, flooring, architraves and cornices, although without limitation thereto. In some embodiments, the panel may provide a relatively cheap and simple product that can be produced and used by third world communities that produce significant amounts of rice straw as a result of rice grain production.

The panel disclosed herein may also provide significant environmental benefits.

Rice production across the world is typified by a large number of small producers who may on average grow only 4-5 hectares of rice a year. Some climates allow for two crops per year with an overall production of 12-16T/ha from that area. Increasing the value of production will improve the living standards of millions of rice growers world wide. Agriculture uses approx. 70% of all water harvested from rivers, streams and underground sources. There is an expectation that this water is managed in a sustainable way in the production of food and fibre. Irrigation farmers are continually seeking to improve the water usage efficiency on their farms as irrigation allocations change with seasonal and other factor impact on the amount of water available to grow crops. Improvements to irrigation methods such as laser grading fields and changes to flow rates are examples. Another way to obtain more value from the crops grown is to utilise more of the plant for other purposes opposed to just selling the grain. This process leads to higher returns for irrigation water used. The present invention provides a new way of utilizing rice straw, which would normally be burnt or otherwise disposed of without any economic benefit to the producer.

Greater utilisation of the rice crop residue after harvest eliminates waste material having to be managed before the next crop can be planted and adds value to the crop income as well as reducing costs of handling waste material.

It is also noted that the use of rice straw in producing panels as disclosed herein may reduce pollution derived from burning the rice straw, also with the potential to attract carbon credits.

Throughout the specification the aim has been to describe the preferred embodiments of the invention without limiting the invention to any one embodiment or specific collection of features. It will therefore be appreciated by those of skill in the art that, in light of the instant disclosure, various modifications and changes can be made in the particular embodiments exemplified without departing from the scope of the present invention.

CLAIMS

1. A panel comprising compressed rice straw bonded with a phenolic resin.
2. A method of producing a panel, said method including the step of compressing rice straw bonded with a phenolic resin to thereby produce the panel.
- 5 3. A panel produced according to the method of Claim 2.
4. A structure comprising the panel of Claim 1 or Claim 3 or produced according to the method of Claim 2.
5. The panel of Claim 1 or Claim 3, the method of Claim 2 or the structure of Claim 4, wherein the rice straw comprises lengths of about 6-8 mm.
- 10 6. The panel of Claim 1, Claim 3 or Claim 5, the method of Claim 2 or Claim 5 or the structure of Claim 4 or Claim 5, wherein the phenolic resin is a phenolic formaldehyde resin.
7. The panel of Claim 1, Claim 3, Claim 5 or Claim 6, the method of Claim 2, Claim 5 or Claim 6 or the structure of any one of Claims 4-6, wherein the rice
- 15 straw is bonded with the phenolic resin at about 2-20% by dry weight.
8. The panel, method or structure of Claim 7, wherein the rice straw is bonded with the phenolic resin at about 10% by dry weight.
9. The panel of any one of Claims 1, 3 or 5-8, the method of any one of Claims 2 or 5-8 or the structure of any one of Claims 4-8, wherein bonding occurs for
- 20 sufficient time and at a suitable elevated temperature and pressure to ensure or facilitate a bonding reaction.
10. The panel, method or structure of Claim 9, wherein the temperature is about 150-250°C.
11. The panel, method or structure of Claim 10, wherein the temperature is about
- 25 200°C.
12. The panel of any one of Claims 1, 3 or 5-11, the method of any one of Claims 2 or 5-11 or the structure of any one of Claims 4-11, wherein the bonding time is about 5-10 minutes.
13. The panel, method or the structure of Claim 12, wherein the bonding time is
- 30 about 7-8 minutes.
14. The panel of any one of Claims 1, 3 or 5-13, the method of any one of Claims 2 or 5-13 or the structure of any one of Claims 4-13, wherein the panel is a flat panel.

15. The panel of any one of Claims 1, 3 or 5-14, the method of any one of Claims 2 or 5-14 or the structure of any one of Claims 4-14, wherein the panel is an extruded panel.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2017/050768

A. CLASSIFICATION OF SUBJECT MATTER

B27N 3/00 (2006.01) E04B 1/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DATABASES: PATENW; IPC/C/CNO/LOW: E04B1/3555, E04B1/12, E04B2/74, E04B1/[74, 92], B27N3/00; Keywords: Rice, Straw, Phenolic, Resin and similar keywords.

ESPACENET AND AUSPAT: Applicant/Inventor name searched; Viewed cited/citing of relevant documents.

Google patents: Panel, compressed rice straw; Wall, panel, compressed rice straw; Compressed rice straw, panel; Panel, compressed rice straw, phenolic resin

Applicant(s)/Inventor(s) name searched in internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

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INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2017/050768
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/0083554 A1 (COMBS et al.) 05 April 2012 para [0001], [0025], [0026], [0033] and [0035]	1 - 4, 14, 15
X	CA 2362718 A1 (DIEFFENBACHER SCHENCK PANEL GMBH) 14 September 2000 See abstract, page 10 lines 1 – 16 and page 4 lines 6 – 14.	1 - 4, 9, 14, 15
X	US 8696958 B1 (MOELLER) 15 April 2014 See abstract, column 1 lines 1 – 6, column 4 lines 1 – 7, lines 18 – 28 and claim 2.	1 - 4, 6, 9 - 14, 15
X	US 4127636 A (FLANDERS) 28 November 1978 See abstract, column 5 lines 41 - 48, column 12 lines 8 - 15	1 - 4, 7 - 11, 14, 15
X	WO 2005/023499 A1 (GORMAN JOHN) 17 March 2005 Entire document	1 - 15