Evaluation Report CCMC 13474-R
TRIFORCE®

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1. Opinion

It is the opinion of the Canadian Construction Materials Centre (CCMC) that "TRIFORCE®," when used as joists in floor applications in accordance with the conditions and limitations stated in Section 3 of this Report, complies with the National Building Code of Canada (NBC) 2015:

- Clause 1.2.1.1.(1)(a) of Division A, using the following acceptable solutions from Division B:
  - Sentence 4.3.1.1.(1), Design Basis for Wood (CAN/CSA-O86-14,"Engineering Design in Wood," Clause 4.3.2 for reliability-based joist strength and stiffness qualification and adhesive qualification.

- Clause 1.2.1.1.(1)(b) of Division A, as an alternative solution that achieves at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the following applicable acceptable solutions:
  - Article 9.10.8.10., Application to Houses (Fire rating is not required for single-family houses constructed as per Part 9 of the NBC, conventional wood-frame construction)[(1)];
  - Sentence 9.23.4.2.(2), Spans for Joists, Rafters and Beams (in other words, alternative floor joist solution)

This opinion is based on CCMC's evaluation of the technical evidence in Section 4 provided by the Report Holder.

[(1)] Sections 4.2 and 4.3 of this Report provide a "fire-protection option" for this proprietary floor joist system as an alternative solution to the acceptable solution in Part 9 for conventional wood-frame floor construction. The proposed joists' fire protection option, referenced in Sections 4.2 and 4.3 and listed in Appendix B, is provided to the authority having jurisdiction (AHJ) for information purposes. The fire-protection option, proposed and explained in Sections 4.2 and 4.3, is provided by the joist manufacturer, and the fire performance has been reviewed by CCMC as performing "as well as" the inherent fire resistance of exposed lumber floors.

Ruling No. 10-02-239 (13474-R) authorizing the use of this product in Ontario, subject to the terms and conditions contained in the Ruling, was made by the Minister of Municipal Affairs and Housing on 2010-03-23 pursuant to s. 29 of the *Building Code Act, 1992* (see Ruling for terms and conditions). This Ruling is subject to periodic revisions and updates.

2. Description

The product is parallel chord trusses with diagonal wood webs. The top and bottom chords are available in either 2 in. × 3 in. or 2 in. × 4 in. finger-jointed proprietary grade lumber (see Figure 1). The diagonal web members are short 2 in. × 2 in. pieces of lumber, finger-jointed into the top and bottom chords. The joists have a trimmable end section at one end and an end post at the other end. The trimmable end section is an 803-mm-long oriented strandboard (OSB) web section, which is similar to an I-joist and can be trimmed in the field a maximum of 610 mm (24 in.) (that is, with 194 mm [7 5/8 in.] remaining). The chord sizes are outlined in Table 2.1.

In the assembly of the floor truss, the web-to-chord fingerjoints and OSB web-to-chord joints are all adhered with a phenol-resorcinol formaldehyde (PRF) adhesive conforming to CSA O112.7, (see CCMC 13213-L) or a PRF conforming to CSA O112.9 (see CCMC 14042-L). The OSB web complies with CAN/CSA-O325-07, "Construction Sheathing," and PS 2. The chord fingerjoints are adhered with either a melamine-based adhesive conforming to CSA O112.9, (see CCMC 13252-L) or one of two polyurethane-based adhesives conforming to CSA O112.10 (see CCMC 13512-L and CCMC 13513-L)).

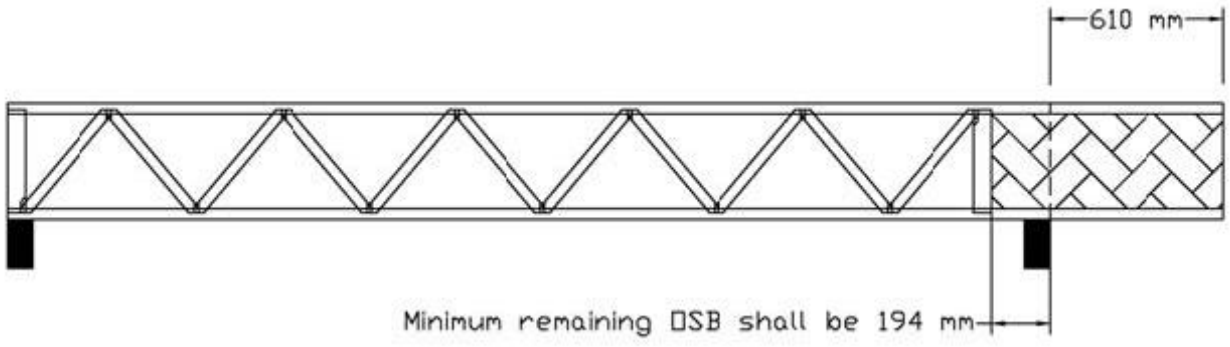

Figure 1. "TRIFORCE®" showing maximum joist OSB end-trimming permitted

Table 2.1 Product Series Descriptions

Series	Joist Depth (mm)	Flange Material(1)	Flange Dimensions (depth × width) (mm)	Diagonal Material	Diagonal Chord Dimensions (depth × width) (mm)	Trimmable End
OJ-314	241-406	G14	38.1 × 63.5	G14	38.1 × 38.1	9.5-mm OSB
OJ-315	241-406	G15 – 1.5E	38.1 × 63.5	G14	38.1 × 38.1	9.5-mm OSB
OJ-318	241-406	G18 – 1.8E	38.1 × 63.5	G14	38.1 × 38.1	9.5-mm OSB
OJ-320	241-406	G20 – 2.0E	38.1 × 63.5	G14	38.1 × 38.1	9.5-mm OSB
OJ-414	241-406	G14	38.1 × 88.9	G14	38.1 × 38.1	9.5-mm OSB
OJ-415	241-406	G15 – 1.5E	38.1 × 88.9	G14	38.1 × 38.1	9.5-mm OSB
OJ-418	241-406	G18 – 1.8E	38.1 × 88.9	G14	38.1 × 38.1	9.5-mm OSB
OJ-420	241-406	G20 – 2.0E	38.1 × 88.9	G14	38.1 × 38.1	9.5-mm OSB

Note to Table 2.1:

(1) All lumber is from the spruce-pine-fir (S-P-F) species group and is subject to proprietary visual grading rules, is periodically tension-tested by the manufacturer, and is third-party verified and certified by Intertek.

3. Conditions and Limitations

CCMC's compliance opinion in Section 1 is bound by the "TRIFORCE®" being used in accordance with the conditions and limitations set out below.

- The product series is intended for use in structural applications, such as floor, ceiling or roof joists, and is intended for dry service use(1) applications only.

  (1) All lumber, wood-based panels and proprietary engineered wood products are intended for dry service conditions. "Dry service" is defined as the in-service environment under which the average equilibrium moisture content (MC) of lumber is 15% or less over a year and does not exceed 19% at any time. Wood contained within the interior of dry, heated or unheated buildings has generally been found to have a MC between 6% and 14%, according to season and location. During construction, all wood-based products should be protected from the weather to ensure that the 19% MC is not exceeded, in accordance with Article 9.3.2.5., Moisture Content, of Division B of the NBC 2015.

- These product series follows a manufacturing quality assurance program (QAP) that is monitored by Intertek. The manufacturing QAP, which is mainly based on the principles of ASTM D 5055, "Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists," has been adapted to include requirements specific to the products and is verified by Intertek as part of the product certification through regular audits. In addition, each joist is proof-tested for a period of 3 to 5 seconds.

- This product series must be identified with the phrase "CCMC 13474-R" along the side of the joist. This CCMC number is only valid when it appears in conjunction with the ETL C+US Certification Mark of Intertek. In addition, there must be an indication that clearly identifies the proper upright orientation for the joist installation, in order to prevent incorrect reverse installation.

- The following pre-engineering information has been provided to CCMC by the manufacturer to demonstrate compliance with Part 9 of the NBC 2015 for acceptance by the local authority having jurisdiction (AHJ):

i. Pre-engineered Floor Span Charts

When the products are used to support uniform loads only, the installation must be in accordance with the span tables (including vibration criteria[(2)]) found in the specifier's guide, in Limit States Design for Canada, entitled:

- "TRIFORCE®" Specifier Guide, dated January 10, 2020 (Canadian Edition)

The products must be installed in accordance with "TRIFORCE®" installation guidelines noted in the above-mentioned document for those applications falling within the scope of the documents. Applications outside the scope of these installation guidelines require engineering on a case-by-case basis as outlined below.

[(2)] In cases where concrete topping is applied or bridging/blocking is used and joists are installed at the maximum spans, the current vibration criteria may not address all occupant performance expectations. Barrette Structural Distribution Inc. should therefore be consulted for span adjustments, if necessary, in these types of installations.

ii. Pre-engineered Installation Details

The pre-engineered details in the documents outlined in (i) above are limited in scope to building designs where the anticipated loads on the following structural details are not exceeded:

- floor span tables;
- maximum trimmable length (610 mm);
- web stiffener details;
- squash blocks; and
- maximum web hole in OSB web trimmable end.

iii. Engineering Required

For structural applications beyond the scope/limitations of the documents referenced in (i) above or when required by the AHJ, the drawings or related documents must bear the authorized seal of a professional engineer skilled in wood design and licensed to practice under the appropriate provincial or territorial legislation.

Installations beyond the scope/limitations of (i) and (ii) imply, but are not limited to, the following:

- rim board resistance;
- loadbearing cantilever tables;
- higher loads / longer spans than the manufacturer's pre-engineered details;
- concentrated loads;
- offset bearing walls;
- areas of high wind or high seismicity;
- stair openings;
- the design of supporting wall studs/beams when the total load/span exceeds the NBC 2015 lumber floor/roof span tables; and
- the design of supporting foundation footings when the total load/span exceeds the NBC 2015 lumber floor/roof span tables.

The engineer must design in accordance with CAN/CSA-O86 and may use as a guide the *Engineering Guide for Wood Frame Construction*, published by the Canadian Wood Council.

iv. Engineering Support Provided by Manufacturer

The manufacturer may provide engineering services in conjunction with the product specifications, and offers the following contact number: 800-263-7265.

4. Technical Evidence

The Report Holder has submitted technical documentation for CCMC's evaluation. Testing was conducted at laboratories recognized by CCMC. The corresponding technical evidence for this product is summarized below.

4.1. Design Values

Table 4.1.1 Engineering Properties of the Product Series

Series	Depth (mm)	Flange Width (mm)	M[(1)] (N.m)	Vr[(2)] (N)	EI^3 (kN.mm^2)	K[(3)] (kN)	F_{cp} Flanges (MPa)	Joist Weight (N/m)
OJ-314	241	63.5	4 868	6 140	4.878E + 08	11 929	5.3	39.42
	302	63.5	6 303	8 828	8.166E + 08	16 470		40.88
	356	63.5	7 548	10 214	1.183E + 09	20 532		41.61
	406	63.5	8 577	10 670	1.590E + 09	24 355		43.07
OJ-315	241	63.5	5 947	6 140	5.226E + 08	11 929	5.3	39.42
	302	63.5	7 700	8 828	8.749E + 08	16 470		40.88
	356	63.5	9 268	10 214	1.267E + 09	20 532		41.61
	406	63.5	10 743	10 670	1.703E + 09	24 355		43.07
OJ-318	241	63.5	8 054	6 140	6.272E + 08	11 929	6.5	39.86
	302	63.5	10 427	8 828	1.050E + 09	16 470		41.32
	356	63.5	12 550	10 214	1.521E + 09	20 532		42.05
	406	63.5	14 549	10 670	2.044E + 09	24 355		43.51
OJ-320	241	63.5	8 294	6 140	6.968E + 08	11 929	6.5	39.86
	302	63.5	10 738	8 828	1.166E + 09	16 470		41.32
	356	63.5	12 924	10 214	1.690E + 09	20 532		42.05
	406	63.5	14 981	10 670	2.271E + 09	24 355		43.51
OJ-414	241	88.9	6 800	6 140	6.829E + 08	14 792	5.3	47.16
	302	88.9	8 803	8 828	1.143E + 09	20 423		48.62
	356	88.9	10 543	10 214	1.656E + 09	25 460		50.08
	406	88.9	11 979	10 670	2.225E + 09	30 200		51.54
OJ-415	241	88.9	8 340	6 140	7.317E + 08	14 792	5.3	47.45
	302	88.9	10 797	8 828	1.225E + 09	20 423		48.91
	356	88.9	12 996	10 214	1.774E + 09	25 460		50.37
	406	88.9	15 065	10 670	2.384E + 09	30 200		51.83
OJ-418	241	88.9	11 471	6 140	8.780E + 08	14 792	6.5	47.45
	302	88.9	14 852	8 828	1.470E + 09	20 423		48.91
	356	88.9	17 876	10 214	2.129E + 09	25 460		50.37
	406	88.9	20 723	10 670	2.861E + 09	30 200		51.83
OJ-420	241	88.9	11 654	6 140	9.755E + 08	14 792	6.5	47.45
	302	88.9	15 088	8 828	1.633E + 09	20 423		48.91
	356	88.9	18 159	10 214	2.365E + 09	25 460		50.37
	406	88.9	21 051	10 670	3.179E + 09	30 200		51.83

Notes to Table 4.1.1:

(1) The factored moment resistances (with Φ included and listed are for standard term load duration) must not be increased by any Code-allowed repetitive member system factor.

(2) The factored shear resistances (with Φ included and listed for standard term load duration) are determined by the web tension resistances.

(3) Mid-span deflection must be predicted using the following formula:

$$\text{deflection} = \frac{5wL^4}{384EI} + \frac{wL^2}{K}$$

where: w = load (kN/mm), L = span (mm), EI and K from Table 4.1.1.

Table 4.1.2 End Reaction Properties of the Product Series

Series	Depth (mm)	Q_r[1][2] (N)				
		Bearing End				
		2 in. × 3 in. End Post		OSB End Panel[3]		
		Bearing Length (mm)				
		38.1	88.9	38.1	38.1	88.9
				Web Stiffener[4]		
				No	Yes	No
OJ-300 and OJ-400	241	10 683	13 339	6 143	7 460	8 692
	302	11 232	14 099	6 468	7 847	9 150
	356	11 723	14 779	7 631	8 407	9 666
	406	12 184	15 420	7 758	9 488	9 827

Notes to Table 4.1.2:

(1) The end reaction resistances (with Φ included) are reference design values for standard term duration load and do not include the verification of the perpendicular compression of the joist flanges. The factored reaction shall not exceed the indicated capacity and the capacity calculated in accordance with CSA O86, using the contact area of the bearing and f_{cp} value of the flanges indicated in Table 4.1.1.

(2) End reactions require a minimum bearing length of 38.1 mm (1.5 in.); interpolation between bearing lengths is permitted.

(3) The OSB section is adjustable up to 610 mm (24 in.) without any modification of the tabulated limit states design properties.

(4) Web stiffeners must be installed in accordance with the products' installation details.

4.2 Additional Performance Data Submitted by the Report Holder

This section is beyond the scope of CCMC's opinion in Section 1 related to the evaluation of structural performance in Section 4.1. The performance of the fire-protection option has been reviewed by CCMC and is presented as additional information for AHJs.

4.2.1 Background

The following information is intended to be used by the AHJ when the fire performance of the alternative solution is deemed to perform "as well as" that of the Code-specified exposed lumber joists. The engineered joist manufacturer (Report Holder) has submitted to CCMC the fire-protection option for its proprietary joist system when used in single-family houses (unsprinklered). The submission was in response to the decision by the Canadian Commission on Construction Materials Evaluations (CCCME), as outlined in Section 4.3 of this Report.

4.2.2 Proposed Fire-Protection Options

The manufacturer's solutions for proposed fire protection of its proprietary joists are presented in Appendix B. CCMC has reviewed the fire testing and analysis of the fire protection options compared to the fire performance of unprotected exposed 38 mm × 235 mm (2 × 10) floor joist system.[1] The fire testing demonstrated that the proposed fire protection options perform "as well as" exposed 38 mm × 235 mm (2 × 10) lumber joists. It should be noted that the NBC exempts single-family houses constructed using conventional wood-frame construction, in accordance with Part 9, from requiring a fire-resistance rating (see Article 9.10.8.10. of Division B of the NBC 2015). The proposed fire-protection options for proprietary alternative floor joists are not to be considered in sprinklered single-family houses or where fire-resistance-rated assemblies are required.

[1] Structural composite lumber, as defined in CSA O86 and evaluated by CCMC, is considered to have equivalent fire performance to lumber for joists of the same size.

4.3 Additional Health and Safety Data Identified by Third Parties

This section is beyond the scope of CCMC's opinion in Section 1 related to the evaluation of structural performance in Section 4.1. The performance of the fire-protection options has been reviewed by CCMC and is presented as additional information for AHJs.

4.3.1 Canadian Commission on Construction Materials Evaluations (CCCME) – Fire Safety

The minimum fire performance of innovative structural materials, or alternative solutions, as compared to that of the NBC-specified conventional wood-frame construction, or acceptable solution, has been the subject of analysis and discussion for several years among fire officials, provincial and territorial regulators, and AHJs. The NRC fire tests[1] conducted between 2002 and 2008 demonstrated that the innovative structural joist systems tested, and currently in the marketplace (i.e., I-joists, C-channel steel joists, metal-plated wood trusses and

metal-web trusses), had a time-to-collapse below the performance of exposed 38 mm × 235 mm (2 × 10) lumber joists (which is considered the benchmark or acceptable solution). At the May 2018 and October 2019 meetings of the CCCME, the Commission directed CCMC to provide floor fire performance information to the local AHJs across Canada to aid their decision-making on whether the fire performance of floors (i.e., the time to evacuate before failure occurs) for alternative joist systems performs "as well as" the inherent fire performance of exposed 38 mm × 235 mm (2 × 10) lumber joists. Testing has been carried out that follows the principles expressed in Appendix D of Division B of the NBC. Following the direction of the CCCME, this CCMC Evaluation Report has been modified to provide this manufacturer's information.

The CCCME asked CCMC to review and validate the fire-test data from manufacturers, and publish the fire performance to assist the AHJ's decision regarding fire protection for alternative solutions to exposed lumber floor joists of conventional wood-frame construction. CCMC has agreed to review the proposed fire protection alternatives and provide the AHJ with valid fire-protection options. It is confirmed that the I-joist fire-protection solutions submitted by this manufacturer have been reviewed by CCMC and are outlined in Appendix B. These joist fire-protection options, tested by following the principles of the CAN/ULC-S101 floor test[(2)], are considered by CCMC as having performed as well as exposed 38 mm × 235 mm (2 × 10) lumber joists.

[(1)] Fire Performance of Houses. Phase I. Study of Unprotected Floor Assemblies in Basement Fire Scenarios, RR-252, 2008-12-15.
[(2)] Essentially following the CAN/ULC-S101 time-temperature curve, the floor joists loaded to in-service loads and structural joist failure as the criterion.

Report Holder

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Date modified:
2020-04-17

Appendix A

The original design values, obtained from testing to CCMC's Technical Guide for "Open Wood-Web Floor Trusses with Trimmable End Section(s) (Proof-Loaded)" and reliability normalization factors, as per CAN/CSA-O86-04, are summarized below and were established for the initial evaluation published in 2010. No changes to normalization factors as per current CSA O86-14 affect these original design values.

Table A1. Additional Test Information

Property	Test Information
Shear capacity	Ten specimens for each depth of the OJ-314 series (40 specimens) were tested, and the characteristic values and 2-P Weibull coefficient of variation, CV_w, were established. The reliability normalization factor was determined following the CSA standard procedure to determine the reliability-based specified strength for limit states design.
Moment capacity	The moment capacity was determined based on the analytical method and confirmed by testing. For the analytical method, a minimum of 53 specimens were tension-tested for each proprietary grade and size of chord (that is, 424 specimens). For verification testing, 10 joist specimens for three depths of 4 series (that is, 120 specimens) were tested. For all tests, the characteristic values and 2-P Weibull coefficient of variation, CV_w, were established. The reliability normalization factor was determined following the CSA standard procedure to determine the reliability-based moment resistance for limit states design. In addition, further testing was conducted to investigate the effect of web-to-chord and chord-to-chord fingerjoints coinciding. No adverse effects on joist strength were observed.
Stiffness	An appropriate test program was used to confirm the stiffness capacity. The following formula was used to predict mid-span deflection: $$deflection = \frac{5wL^4}{384EI} + \frac{wL^2}{K}$$ where: w = load (kN/mm), L = span (mm), EI from Table 4.1.1, and K from Table 4.1.1.
End joints	End joints were qualified as part of the flange tension qualification by the finger-jointed lumber supplier certified by a certification officer (CO). The manufacturer conducts periodic tension tests to confirm the chord tension specified strength.
Creep	Specimens were tested for creep performance in accordance with: (i) ASTM D 5055 and (ii) the 24-hour CCMC creep and recovery test. The ASTM D 5055 specimens recovered more than 90% of the basic dead load deflection. All specimens passed the CCMC creep and recovery criteria.
Bearing length	The product reaction properties listed in Table 4.1.2 are specific to bearing lengths shown for the end post and OSB web end, with and without web stiffeners. A minimum of 10 specimens were tested for each combination of bearing length configuration for the shallowest and deepest joist (that is, 117 specimens). The characteristic values and 2-P Weibull coefficient of variation, CV_w, were established. The reliability normalization factor was determined following the CSA standard procedure to determine the reliability-based specified strength for limit states design.
Adhesive qualification	The chord fingerjoints are either adhered with a melamine-based adhesive conforming to CSA O112.9, "Evaluation of Adhesives for Structural Wood Products (Exterior Exposure)" (see CCMC 13252-L), or adhered with a polyurethane-based adhesive conforming to CSA O112.10, "Evaluation of Adhesives for Structural Wood Products (Limited Moisture Exposure)", (see CCMC 13512-L and CCMC 13513-L)). The web-to-chord fingerjoints and OSB web-to-chord joints are all adhered with a phenol-resorcinol formaldehyde (PRF) adhesive conforming to CSA O112.7 , "Resorcinol and Phenol-Resorcinol Resin Adhesives for Wood (Room- and Intermediate-Temperature Curing)" (see CCMC 13213-L) or PRF confirming to CSA O112.9 (see CCMC 14042-L)
Web stock	The OSB web stock complies with CAN/CSA-O325 based on certification by a Certification Organization..

Appendix B

B-1 CCMC Important Note from the CCMC Registry of Product Evaluations

Fire Performance of Innovative Structural Products in Houses

This Registry contains opinions on the suitability-for-use of products intended as structural elements in houses. Although historically there has been no need to regulate the structural fire performance of houses, an inherent intent of the National Building Code of Canada (NBC) is that occupants have sufficient time to escape from a building in the event of a fire.

There are many factors that may determine whether that intent is achieved. The fire endurance of structural elements may be one. However, its importance may be minimized by other factors such as combustible content load, early warning devices, smoke movement and toxicity, and fire department response time; all contributing to the overall system performance. Research is underway within the NRC Construction Research Centre to determine the critical factors that affect occupant escape from houses.

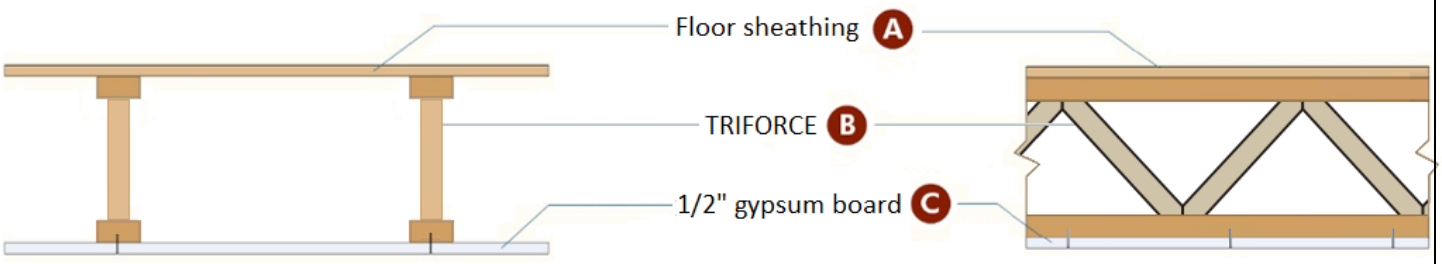
Some innovative structural products have been used in the marketplace for several years and have gained the confidence of design professionals, code authorities and users with respect to their performance under typical fire scenarios in today's house system. Some newer products have not been in service long enough to have gained that confidence and may present a more obvious concern.

Unless otherwise stated, innovative structural products for houses have not been evaluated in the context of the NBC intent noted above. As is the case for all innovative products, designers and authorities need to exercise judgment in considering the use of innovative structural products for houses.

B-2 "TRIFORCE®" – Fire-Protection Options

The following floor assembly design (Figure 1) is the default alternative solution for all cases and where the manufacturer has not undertaken any specific testing to show equivalency to exposed 38 mm × 235 mm (2 × 10) lumber with proprietary joist fire protection options.

12.5 MM (1/2 IN.) GYPSUM BOARD ATTACHED TO BOTTOM OF FLANGE



A. Floor sheathing: materials and installation in accordance with the NBC 2015.

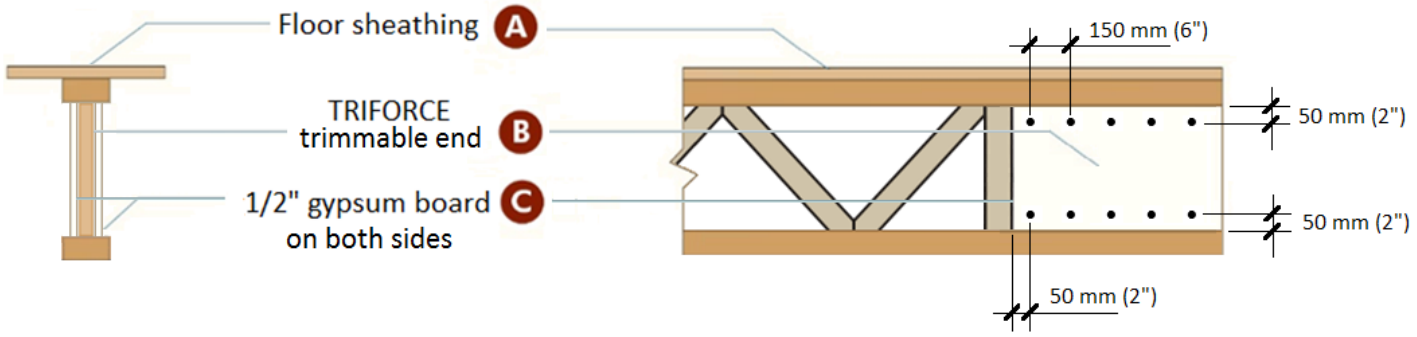
B. I-joist: installation in accordance with Section 3 of this Report. Maximum 24 in. on centre (o.c.) spacing. Applicable to all flange sizes.

C. 12.5 mm (1/2 in.) regular gypsum board: materials and installation in accordance with the NBC 2015. 1 × 3 (nominal) wood furring strips are permitted to be installed perpendicular to the bottom flange of the "TRIFORCE®" Joist at 400 mm (16 in.) o.c. provided that the gypsum boards are directly attached to the furring strips using 32 mm (1-1/4 in.) Type W drywall screws at 300 mm (12 in.) o.c. Gypsum board not required to be finished with tape and joint compound.

Figure 1. Fire Protection of Floors FP-01 – Fire Protection: 12.5 mm (1/2 in.) Regular Gypsum Board Attached to Bottom of Flange

The following floor assembly design (Figure 2) is provided by the manufacturer and provides fire performance as well as exposed 38 mm × 235 mm (2 × 10) dimensional lumber floor joists.

12.5 MM (1/2 IN.) REGULAR GYPSUM BOARD OR OPTIONAL 15 MM (19/32 IN.) WOOD STRUCTURAL PANEL ATTACHED TO BOTH SIDES OF TRIMMABLE END OSB



A. **Floor sheathing: materials and installation in accordance with the NBC 2015.**

B. **I-joist: Installation in accordance with Section 3 of this Report. Maximum 600 mm (24 in.) on centre (o.c.) spacing. Applicable to all flange sizes.**

C. **12.5 mm (1/2 in.) regular gypsum board or optional 15 mm (19/32 in.) wood structural panel: Installed on both sides of the trimmable end OSB with fasteners on both sides, 25 mm (1.0 in.) screws or 25 mm (1.0 in.) nails or 9.5 mm (3/8 in.) × 25 mm (1.0 in.) staples × 15 or 16 gauge staples at 150 mm (6 in.) o.c. with 50 mm (2 in.) edge spacing or 6mm (¼ in.) to 9.5 mm (3/8 in.) bead in a "Z-pattern" of PL400 adhesive per manufacturer's instructions.**

Figure 2. Manufacturer's proprietary fire-protection solution with gypsum board or optional wood structural panel protected trimmable end