



Three Pontoon Displacement and Draft Analysis for 2 ft by 8 ft by 60 ft Rectangular Hulls Supporting a 20,000 lb Superstructure

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<https://electricship.com/ferrocement-hull-concept.html>

Engineering estimate of displacement and submerged draft for a trimaran style platform using three 2 ft by 8 ft by 60 ft pontoons spaced 15 ft apart, comparing steel, fiberglass over foam, and ferrocement over foam hull constructions.



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Three Pontoon Displacement and Draft Analysis

Using simple hydrostatics for a rectangular pontoon, draft is set by total weight divided by waterplane area and water density. Below are displacement and submergence estimates for three hull material options, plus practical naval-architecture implications for freeboard and stability.

Configuration and Assumptions

Geometry (each pontoon):

- Width = 2 ft
- Height = 8 ft
- Length = 60 ft
- Waterplane area per pontoon = $2 \times 60 = 120 \text{ ft}^2$
- Total waterplane area for three pontoons = $3 \times 120 = 360 \text{ ft}^2$

Loads:

- Superstructure weight (total) = 20,000 lb
- Hull self-weight depends on material option (from prior skin and foam estimates).
- Assumes: closed watertight hulls, load shared across all three pontoons, negligible dynamic effects, no additional payload, no free-surface flooding, and dimensions represent the outer box at the waterline.

Water density:

- Freshwater: 62.4 lb/ft^3 (typical inland lakes and rivers)
- Saltwater: about 64.0 lb/ft^3 (draft is slightly less)

Key hydrostatic relations (rectangular pontoons):

- Total displacement volume, (V) = Total weight / water density
- Draft, (T) = Total weight / (water density \times total waterplane area)

Hull Weight Inputs Used

These are the same order-of-magnitude weights previously computed (shell plus foam where applicable), used here so draft reflects the material choice:

1. 1/4 inch welded steel shell (no interior foam): ~12,600 lb per pontoon (skin only, stiffeners not included)
 2. Foam blocks with 1/4 inch fiberglass outer skin: ~5,850 lb per pontoon (representative mid case: FRP skin plus light foam)
 3. Foam blocks with 1/2 inch ferrocement plus wire mesh, with sprayed HDPE coating: ~10,300 lb per pontoon (representative mid case: concrete shell plus light foam)
- If your final build includes heavy internal frames, deck stringers, bulkheads, or machinery, add that weight to the totals and draft increases linearly.

Results in Freshwater

Total platform weight = Superstructure + $3 \times$ (pontoon weight)

Option 1: 1/4 inch welded steel, empty interior

- Total weight = $20,000 + 3 \times 12,600 = 57,800 \text{ lb}$
- Total displacement volume = $57,800 / 62.4 = 926.3 \text{ ft}^3$
- Draft = $57,800 / (62.4 \times 360) = 2.573 \text{ ft} = 30.88 \text{ in}$
- Freeboard (to top of 8 ft hull) = $8.0 - 2.573 = 5.43 \text{ ft}$

Option 2: Foam blocks with 1/4 inch fiberglass outer skin

- Total weight = $20,000 + 3 \times 5,850 = 37,550 \text{ lb}$
- Total displacement volume = $37,550 / 62.4 = 601.8 \text{ ft}^3$

Preliminary Trimaran Pontoon Stability and Crossbeam Load Analysis for Three 2 ft by 8 ft by 60 ft Hulls Supporting a 20,000 lb Superstructure

Naval-architecture estimate of draft, center of gravity, transverse metacentric height, and wave-induced differential buoyancy loads for a three-pontoon platform using 2 ft by 8 ft by 60 ft rectangular watertight hulls spaced 15 ft apart.

A three-hull pontoon platform has enormous initial (small-angle) stability because the buoyancy acts at widely separated hull centerlines. The design driver becomes structural: crossbeam torsion and racking loads from uneven wave support can be far larger than the static draft problem.

1) Geometry and Known Loads

Each pontoon (rectangular box):

- Width ($b = 2$, \text{ft})
- Height ($h = 8$, \text{ft})
- Length ($L = 60$, \text{ft})

Waterplane area per pontoon:

$$A_{\text{wp},1} = bL = 2 \times 60 = 120 , \text{ft}^2$$

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Total waterplane area (3 hulls):

$$A_{\text{wp,total}} = 360 , \text{ft}^2$$

]

Hull spacing: three hulls with 15 ft separation between hulls. For analysis, I assume a classic trimaran layout:

- center hull at ($y=0$)
- outer hull centerlines at ($y=\pm 15$) ft

So outer-to-outer centerline separation is 30 ft.

Superstructure weight: ($W_{\text{sup}}=20{,}000$) lb total.

Water density: freshwater ($\rho = 62.4$, \text{lb/ft}^3)

2) Draft Recap (Freshwater) Using Your Three Material Cases

From the prior weight estimates (representative mid-cases):

- Steel option: total weight ($W \approx 57{,}800$) lb \rightarrow draft ($T \approx 2.573$) ft (30.9 in)
- FRP over foam option: ($W \approx 37{,}550$) lb \rightarrow ($T \approx 1.672$) ft (20.1 in)
- Ferrocement over foam option: ($W \approx 50{,}900$) lb \rightarrow ($T \approx 2.266$) ft (27.2 in)

These drafts matter for freeboard and KB (center of buoyancy height).

3) Center of Buoyancy (KB) and Center of Gravity (KG)

3.1 KB for a rectangular pontoon

For a boxy hull at small angles, the center of buoyancy is approximately at mid-draft:

$$KB \approx \frac{T}{2}$$

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So:

- Steel: ($KB \approx 1.286$) ft
- FRP: ($KB \approx 0.836$) ft
- Ferrocement: ($KB \approx 1.133$) ft

3.2 KG estimate (dominant driver is superstructure height)

You didn't specify the superstructure CG height, so I have to assume a reasonable preliminary value.

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- Height ($h = 8$, ft)
- Length ($L = 60$, ft)

Waterplane area per pontoon:

$$A_{\text{wp},1} = bL = 2 \times 60 = 120, \text{ft}^2$$

Total waterplane area (3 hulls):

$$A_{\text{wp,total}} = 360, \text{ft}^2$$

Hull spacing: three hulls with 15 ft separation between hulls. For analysis, I assume a classic trimaran layout:

- center hull at ($y=0$)
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...

Offshore Trimaran Pontoon Engineering Estimate for 3 ft Differential Heave: Stability, Buoyancy Imbalance, and Crossbeam Torsion Loads

Preliminary naval-architecture and structural load estimate for a three-pontoon platform (2 ft by 8 ft by 60 ft hulls spaced 15 ft) supporting a 20,000 lb superstructure offshore. Includes GM trend, 3 ft differential heave buoyancy imbalance, torsional couple, and practical crossbeam and deck-diaphragm design targets.

For a three-hull pontoon platform, small-angle stability is abundant due to the wide stance, but offshore performance is governed by bridging structure. A 3 ft differential heave between outer hulls creates a large buoyancy imbalance and a torsional couple that must be carried by crossbeams, deck diaphragm action, and robust hull hardpoints.

1) Baseline Geometry and Hydrostatics Used

Each pontoon (rectangular watertight box): 2 ft (beam) × 8 ft (depth) × 60 ft (length)

Waterplane area per pontoon:

$$A_{wp,1} = 2 \times 60 = 120 \text{ ft}^2$$

Trimaran layout (assumed):

- Center hull at $y = 0$
- Outer hull centerlines at $y = \pm 15$ ft
- Outer-to-outer lever arm = 30 ft

Water density: freshwater ($\rho = 62.4 \text{ lb/ft}^3$) (saltwater reduces drafts and increases buoyancy ~2-3%)

Key stiffness metric (for vertical support changes):

$$\frac{dF}{dT} \bigg|_{\text{per hull}} = \rho \cdot A_{wp,1} = 62.4 \times 120 = 7,488 \text{ lb/ft}$$

That is 624 lb per inch per hull.

2) Offshore Case: 3 ft Differential Heave Between Outer Hulls

You specified offshore with 3 ft heave. For a conservative bridging load, treat this as a 3 ft relative support change between the two outer hulls (one “up” relative to mean, one “down” relative to mean). Using linear hydrostatics:

2.1 Buoyancy imbalance magnitude

For one hull experiencing a 3 ft change in effective immersion:

$$\Delta F = 7,488 \times 3 = 22,464 \text{ lb}$$

If one outer hull gains (+22,464) lb while the other loses (-22,464) lb, the buoyancy difference between outer hulls is:

$$\Delta F_{\text{outer-to-outer}} = 44,928 \text{ lb}$$

2.2 Torsional couple on the bridging structure

The twisting couple about the centerline is approximately:

$$M_{\text{torsion}} \approx \Delta F \times 30 = 22,464 \times 30 = 673,920 \text{ ft-lb}$$

Structural design and analysis should be completed on a regular basis to verify the system's ability to resist the system's 673,920 ft-lb of twisting couple for this 3 ft differential heave case. Refer to the

Offshore Trimaran Pontoon Stability and Structural Loads with 30 ft Beam and 16 ft Superstructure

Engineering estimate of stability, center of gravity, torsional bridging loads, and offshore structural requirements for a three pontoon platform with 30 ft overall beam, 16 ft superstructure height, and 3 ft differential wave heave.

With a 30 ft overall beam and tall superstructure, offshore performance is governed less by tipping and more by structural torsion between hulls. This analysis updates stability, center of gravity, and crossbeam loads for a 3 ft offshore heave condition.

1) Updated Geometry and Reference Levels

Platform type: trimaran style pontoon platform

Number of hulls: 3

Each hull: 2 ft wide × 8 ft tall × 60 ft long

Overall platform beam (outside to outside): 30 ft

Since each outer hull is 2 ft wide, the centerline spacing between outer hulls becomes:

- 30 ft overall – 1 ft – 1 ft
- 28 ft centerline separation

So the torsion lever arm between outer hull buoyancy forces is 28 ft (not 30 ft used previously).

2) Vertical Arrangement

You provided:

- Air draft above water ≈ 16 ft superstructure + 5 ft hull freeboard
- Therefore hull top sits about 5 ft above waterline
- Hull height = 8 ft
- Draft ≈ 3 ft (consistent with earlier weight cases)

Crossbeams

Below is a preliminary composite box-girder crossbeam concept sized to carry the offshore 3 ft differential heave torsion you specified, with an explicit fatigue safety factor, plus beam spacing and deck diaphragm recommendations. This is a concept-level scantling (good for early weight/cost/layout), not class-approved.

1) Design load to size the crossbeams

From your geometry:

- Overall platform beam (outside-to-outside) = 30 ft
- Outer hull width = 2 ft each → outer hull centerline spacing = $30 - 1 - 1 = 28$ ft
- Waterplane area per hull = $2 \times 60 = 120$ ft²
- Buoyancy stiffness per hull = $62.4 \times 120 = 7,488$ lb/ft
- Differential heave = 3 ft

Buoyancy change on one outer hull:

- $\Delta F = 7,488 \times 3 = 22,464$ lb

Torsional couple about the centerline (outer hulls):

- $M_{total} = 22,464 \times 28 \approx 629,000$ ft-lb

How many primary beam stations?

Offshore + fatigue: I recommend 7 primary crossbeams across the 60 ft length (\approx every 10 ft), tied together with longitudinal box girders and a structural deck diaphragm.

Torsion per beam station (equal-share first cut):

- $T_{per} \approx 629,000 / 7 = 89,900$ ft-lb

Fatigue / offshore safety factor

For cyclic offshore torsion + uncertainties in load sharing, use SF = 2.0 on torsion for preliminary sizing:

- $T_{design\ per\ beam} \approx 180,000$ ft-lb

Load Sharing Crossbeams

Below is a more realistic load-sharing model (deck diaphragm + longitudinal girders) and a bending check for a credible offshore “one outrigger in crest / the other in trough / center partially supported” scenario. Then I adjust the composite box-girder section accordingly.
This is still preliminary scantling-level (concept design). Final design should be checked to a chosen ruleset (ABS/DNV/ISO) with a wave spectrum, fatigue category, and connection details.

1) Known platform numbers (recap)

Trimaran pontoons

- 3 hulls, each: 2 ft × 8 ft × 60 ft
- Overall beam outside-to-outside: 30 ft
- Outer hull centerline spacing: 30 – 1 – 1 = 28 ft
- Center hull at midline; outer hulls at ±14 ft.

Hydrostatic “spring” per hull

- Waterplane area per hull: $(A_{wp})=2 \times 60=120 \text{ ft}^2$
- Fresh water ($\rho = 62.4 \text{ lb/ft}^3$)
- Vertical stiffness per hull:

$$k_h = \rho A_{wp} = 62.4 \times 120 = 7,488 \text{ lb/ft}$$

Offshore differential heave specified

- Relative heave between outer hulls: 3 ft
- Buoyancy change magnitude per outer hull:

$$\Delta F = k_h \times 3 = 7,488 \times 3 = 22,464 \text{ lb}$$

- Resulting torsional couple (about centerline):

$$M_{\text{global}} = \Delta F \times 28 = 22,464 \times 28 \approx 629,000 \text{ ft-lb}$$

This (M_{global}) is the “platform twist demand” generated by the sea state.

2) More realistic torsion distribution (deck + longitudinal reduce peak demand per crossbeam)

2.1 Why the earlier “equal share by N beams” is conservative

If you have:

- a stiff deck diaphragm (shear panel),
- two longitudinal box girders (port and starboard) running the length,
- and multiple transverse beams,

...then the platform behaves like a torsion box. In a torsion box, torque is carried continuously as shear flow around the perimeter, not dumped into a single crossbeam station.

So the right quantity to size a given crossbeam for is torque transfer between bays, not the full global torque.

2.2 A practical torsion-sharing model (bays + participating length)

For offshore waves, the “outer hull crest vs trough” condition does not occur at a single cross-section; it is distributed over some participating length (L_p). A reasonable preliminary value is ~30 ft

Vertical Post as Torsional Control

Got it. Those 2x2x24 ft vertical posts at 8 ft spacing, integral to each hull and tied into the superstructure, materially change the load path:

- The platform is no longer just three pontoons bridged by a few deep crossbeams.
- You now have a 3D space frame: pontoons + a forest of vertical stanchions + a superstructure that can act as a torsion box / Vierendeel frame.
- Offshore differential buoyancy loads can be shared along the length through the post grid, rather than being forced through a small number of discrete crossbeam stations.

Below is a reassessment specifically for superstructure crossbeams fastened to the posts.

- 1) Clarify the framing grid implied by your description
 - Post spacing along length: 8 ft
 - Hull length: 60 ft → approx 8 bays (0, 8, 16, 24, 32, 40, 48, 56, 60). In practice you'll have ~8 full bays plus end framing.
 - Rows of posts: 3 rows (one per hull)
 - Transverse span between outer hull post lines:
 - Outer hull centerlines spaced 28 ft
 - If posts are near hull centerlines, the main transverse span between port and starboard post lines is ~28 ft
 - Centerline row at midspan.

This means your superstructure sees something close to a multi-bay, multi-row grillage.

- 2) Offshore 3 ft differential heave: how the load distributes into the post grid

Using the same hydrostatic stiffness per hull:

- ($k_h = 7,488$, \text{lb/ft})
- Outer-to-outer relative heave: 3 ft → each outer hull buoyancy change magnitude:

- ($\Delta F = 22,464$, \text{lb})

Key difference now

Instead of one crossbeam station takes a big torque, the post grid spreads this into multiple frames.

A reasonable first-cut assumption for preliminary sizing is that the wave-induced buoyancy mismatch is effective over a participating length (L_p) offshore. A common preliminary value is still ~30 ft (half the platform length).

Number of post frames engaged:

- ($N = L_p / 8 \approx 30/8 \approx 3.75$) → use 4 frames engaged at peak.

So the outer-hull buoyancy change per engaged frame is roughly:

$$\Delta F_{\text{frame}} \approx 22,464 / 4 \approx 5,616 \text{ , \text{lb}}$$

That means at peak:

- one outer hull post line is pushing up ~5,600 lb per frame,
- the other outer hull is dropping out by ~5,600 lb per frame,
- the center hull may be partially supported (often intermediate)

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Post Assessment

Below is a reassessment with your updates:

- Posts: 2 ft × 2 ft × 24 ft, integral to each hull
 - Post frames: every 8 ft along 60 ft length
 - Superstructure: solid side panels (acts as shear walls / torsion box)
 - Offshore case: 3 ft differential heave between outer hulls
 - Overall beam: 30 ft outside-to-outside → outer-hull CL spacing \approx 28 ft (lever arm)
- This changes the system from a few giant crossbeams to a multi-bay space frame / torsion box, so peak demand on any single crossbeam is materially reduced—provided you actually detail the deck + side panels as structural shear diaphragms.

1) Post axial load and buckling check

1.1 How many posts?

Along 60 ft with 8 ft spacing, you have about 9 frames (at ~0, 8, 16, 24, 32, 40, 48, 56, 60).

Each frame has 3 posts (one per hull row) → 27 posts total.

1.2 Gravity axial per post (superstructure only)

Superstructure weight = 20,000 lb.

If distributed evenly to all posts:

- ~740 lb/post (20,000 / 27)

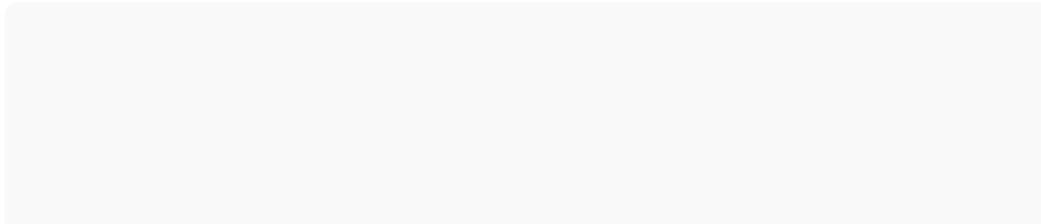
Even if you assume nonuniform distribution and use 2× for conservatism:

- ~1,500 lb/post gravity axial

This is small relative to the section size.

1.3 Offshore wave-induced axial at a post frame (order-of-magnitude)

From hydrostatics:



Analysis of Box Beams

Below is a frame-by-frame (8 ft bay) force model that is consistent with:

- 3 ft offshore differential heave (outer hulls crest/trough),
- 30 ft overall beam → 28 ft outer-hull centerline spacing,
- solid side panels (shear walls) + deck diaphragm (torsion box behavior),
- continuous port-to-starboard transverse box beam at each 8 ft station,
- posts are 2 ft × 2 ft composite (glass + carbon).

I'm going to give you (1) axial in each post, (2) shear in each connection, and (3) moment demand at the node, with explicit assumptions and conservative design factors.

1) Offshore torsion demand converted into per-frame nodal verticals

1.1 Global torsional couple from hydrostatics

Per your earlier case, outer hull buoyancy change magnitude:

- $(k_h = 62.4 \times 120 = 7,488 \text{ lb/ft per hull})$
- $(\Delta T = 3 \text{ ft})$
- $(\Delta F = 7,488 \times 3 = 22,464 \text{ lb})$

Global torsional couple about centerline (lever arm 28 ft):

- $(M_{\text{global}} = 22,464 \times 28 \approx 629,000 \text{ ft-lb})$

1.2 Distributing along length (solid side panels + deck = torsion box)

Offshore, the crest vs trough condition is distributed. A reasonable preliminary participating length is:

- $(L_p \approx 30 \text{ ft})$

Your transverse frames are every 8 ft, so number of engaged frames:

- $(N \approx L_p/8 \approx 3.75 \rightarrow 4)$

So the torsion demand per engaged frame is:

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Ply Schedule for Fiberglass and Carbon

Below is a specific, buildable ply schedule for:

- Transverse box beam: 24 in deep × 12 in wide, continuous port-to-starboard
 - Sandwich walls: skins 0.10 in each, core 1.25 in
 - Carbon UD caps top and bottom
 - Solid node blocks at each post (port, center, starboard)
- Side panels: sandwich shear walls (offshore fatigue-oriented)

I'm assuming a marine epoxy or vinyl ester system, vacuum infusion (or prepreg if you prefer), and stitched biax glass fabrics as the baseline with carbon UD for caps.

To keep this specific, I'll specify plies by fabric type and a target cured thickness per ply. Exact ply counts will vary slightly with your chosen areal weights and resin content, but this gives you a clean, repeatable recipe.

A) Material set and thickness basis (so the ply schedule is unambiguous)

Glass fabrics (typical stitched E-glass)

Use one of these consistent families:

- E-glass biax ±45 (stitched): 0.020 in cured thickness per ply (typical for ~600–800 g/m² class infused)
- E-glass biax 0/90 (stitched): 0.020 in cured thickness per ply

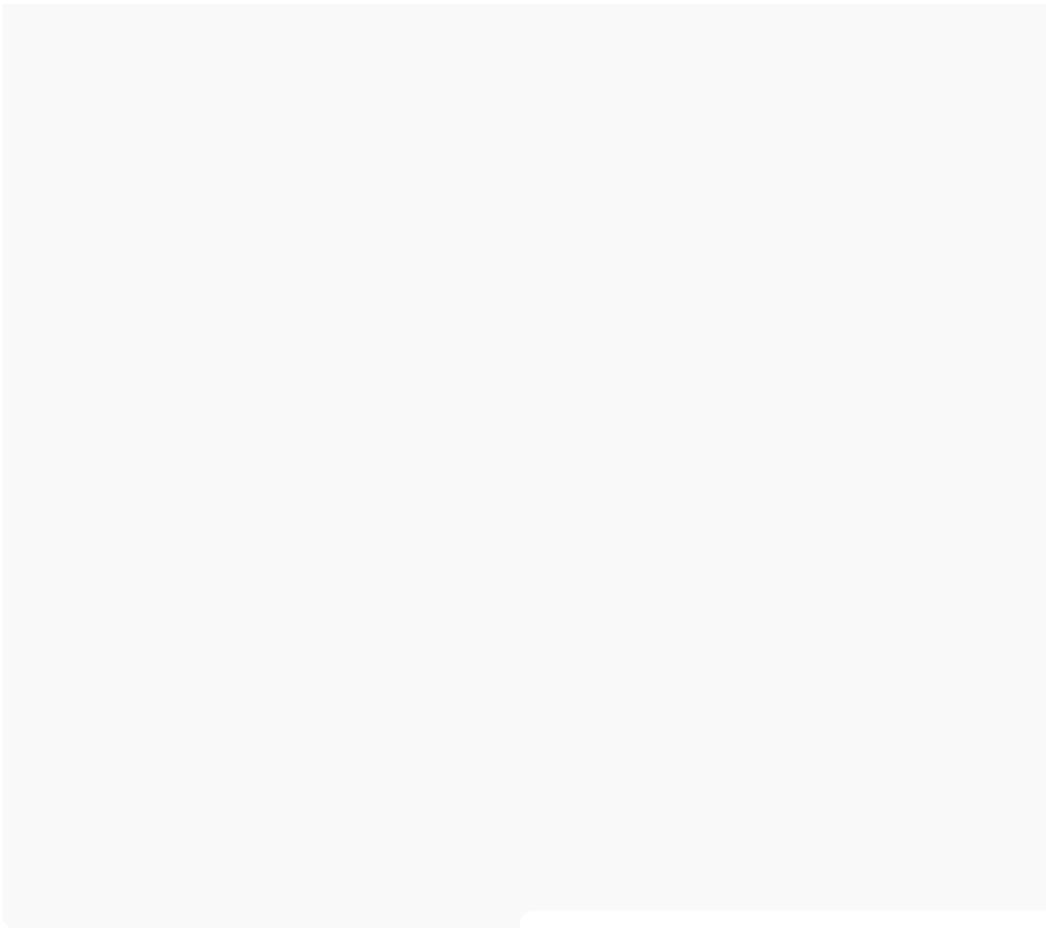
Carbon UD

- Carbon UD tape/fabric: 0.010 in cured thickness per UD ply (typical for ~300–400 g/m² infused)
 - If your UD is heavier (e.g., 600 g/m²), use ~0.020 in per ply and halve the ply count.

Core

- Core thickness: 1.25 in closed-cell structural foam (H100–H130 range; use higher density near nodes)

B) Transverse box beam global laminate schedule (away from nodes)



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