CONRAIL

MEMORANDUM

G-4 R3 12-76
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TO W.C. Humphreys LOCATION

FROM J.A. Hawley /JFM LOCATION

SUBJECT Intermodal Facility, Columbus, Ohio
— Building Design

The behavior of the Tractor/Trailer repair building, as designed, has been examined to ensure that the masonry walls will not be adversely affected; as per your request during the meeting of 3-27-86.

Recommendations are included and sketches attached.

Specific recommendations are made on pages 5, 7, 9, & 13, & 15.

It should be noted that the steel frames are already erected.

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(1)

THE USE OF A FULL-HEIGHT EXTERIOR MASONRY WALL WITH A STEEL RIGID FRAME POSES PROBLEMS THAT ARE NOT ENCOUNTERED WHEN A LOW MASONRY WALL WITH STEEL ABOVE, OR AN ALL-STEEL WALL IS USED. THE TRACTOR/TRAILER BUILDING IS FURTHER COMPLICATED BY THREE DIFFERENT EAVE HEIGHTS AND FULL-HEIGHT, TRANSVERSE MASONRY WALLS AT EACH CHANGE IN EAVE HEIGHT.

SINCE A MASONRY WALL IS USUALLY VERY RIGID IN ITS OWN PLANE, ANY POTENTIAL MOVEMENT OF THE STEEL FRAME PARALLEL TO THE PLANE OF THE WALL WILL TRANSMIT LOAD TO THE WALL, DEPENDING ON THE RELATIVE STIFFNESSES OF THE FRAME AND THE CONNECTION OF THE FRAME TO THE WALL. ALSO, ANY MOVEMENT OF THE FRAME TRANSVERSE TO THE WALL, WHICH CAUSES DIFFERENTIAL MOVEMENT BETWEEN THE TOP AND BOTTOM OF THE WALL, WILL INDUCE BENDING STRESSES IN THE WALL, WHICH, IF EXCESSIVE, WILL OPEN THE HORIZONTAL JOINTS. VERTICAL WALL REINFORCING MAY BE REQUIRED TO HOLD THESE JOINTS TOGETHER.

THE FRAME DESIGNS, IN BOTH DIRECTIONS, PREPARED BY AMERICAN BUILDINGS, (ABC), ARE BASED ON AN ASSUMPTION THAT THE RIGID FRAMES RESIST ALL THE LOAD APPLIED TO THE BUILDING. THIS IS CONSERVATIVE FOR FRAME DESIGN AND IS STANDARD PRACTICE FOR METAL BUILDING MANUFACTURERS WHEN DESIGNING METAL BUILDINGS.

UNLESS THE FRAME DESIGNER IS INFORMED OF, OR KNOWS ABOUT, SPECIAL REQUIREMENTS FOR NON-STANDARD BUILDING COMPONENTS, HE WILL DESIGN THE FRAMES AS IF FOR A STANDARD ALL-METAL BUILDING. FOR EXAMPLE, UNLESS THE DESIGNER IS TOLD TO LIMIT DEFLECTIONS, HE WILL DESIGN STANDARD FRAMES, UTILIZING HIGH-STRENGTH STEEL, THAT ARE RELATIVELY FLEXIBLE.

MORE IMPORTANTLY, THE FRAME DESIGNER MAY NOT CONSIDER THE POSSIBILITY THAT OTHER BUILDING COMPONENTS, SUCH AS MASONRY WALLS, MAY LIMIT THE FREEDOM OF THE FRAME TO DEFLECT, (THEREBY CAUSING LOAD TO BE TRANSFERRED FROM THE FRAME TO THE LIMITING COMPONENT), OR MAY BE FORCED TO FOLLOW THE FRAME, (THEREBY SUFFERING INDUCED STRESSES). AS FAR AS THE DESIGNER IS CONCERNED, THE FRAME IS DESIGNED TO TAKE ALL THE LOAD, SO IT MUST BE CORRECT.

THE PROBLEM IS THAT, WITHOUT ADEQUATE DIRECTION FROM THE BUILDING PLANNER, THE FRAME DESIGNER MAY NOT

CONSIDER HIMSELF RESPONSIBLE FOR DETERMINING THESE EFFECTS, EVEN THOUGH IT MAY SEEM OBVIOUS THAT HE SHOULD.

FOR EXAMPLE, WITHOUT THE NECESSARY COORDINATION THE FRAME DESIGNER MAY SUBMIT AN INCORRECT DESCRIPTION OF THE FRAME REACTION LOADS TO BE SUPPORTED BY THE FOUNDATIONS. OTHER BUILDING COMPONENTS MAY ACTUALLY BE SUPPORTING LOAD DUE TO FRAME BEHAVIOR. FOUNDATIONS UNDER THESE COMPONENTS MAY THEN BE INADEQUATE.

WIND AGAINST THE SIDEWALLS IS TRANSMITTED BY THE WALL TO THE RIGID FRAME COLUMNS AND TO OTHER SUPPORTS INCLUDING THE FOUNDATION WALL, THE SECOND FLOOR IN THE OFFICE AREA AND THE ENDWALLS AT THE BUILDING CORNERS.

OUR MEMO TO YOU, OF 2-19-86, SUGGESTED THE POSSIBLE NEED FOR VERTICAL REINFORCING IN THE SIDEWALLS, PARTICULARLY IN THE 30 FOOT HIGH SECTION. THIS REINFORCING WILL NOT BE REQUIRED FOR THE FOLLOWING REASONS:

- THE MAIN FRAME DEFLECTIONS HAVE BEEN REDUCED, AS SUGGESTED IN OUR MEMO OF 2-19. SEE NOTE 1.
- THE 3.7 INCH DEFLECTION IN THE 30 FOOT SECTION IS A COMBINATION OF WIND, (1.7 INCHES), AND CRANE LATERAL LOAD, (2 INCHES). THE PROBABILITY OF BOTH MAXIMUM LOADS OCCURING TOGETHER IS VERY LOW.
- DIAPHRAGM-SHEARWALL ACTION, AS DESCRIBED BELOW.

To some degree, the roof acts as a beam, (or diaphragm), loaded by the frames and spanning between supports. These supports can be braced end frames, adjacent stiffer frames or masonry shearwalls. Depending on the building geometry, roof stiffness, and support stiffness this action may reduce the frame deflections significantly; (see note 2). However, load is transferred to the supports.

As presently designed, frames 8 and 9 will transmit load, through the roof, to frames 7 & 10. This will also be the case for frames 2-4 transmitting load to frames 1 and 5.

Frame 7 is composed of a 6 foot high braced frame on top of a 24 foot high main frame. As now designed, the top frame is anchored to the transverse masonry wall only at the interior stub columns. The anchors connecting these columns to the wall will transmit load from frame 7 to the wall as the frame

ATTEMPTS TO MOVE PARALLEL TO THE WALL.

THE STUB COLUMNS WILL BE SUBJECT TO WEAK AXIS BENDING AND TORSION. AMERICAN BUILDINGS DID NOT DESIGN THESE COLUMNS FOR SUCH LOAD.

THE BLOCK BELOW THE PURLINS IS DETAILED ON SHEET A5 TO BE "TIGHT TO PURLIN", BUT NO CONNECTION IS CALLED FOR. A STRONG CONNECTION AT FRAMES 1, 5 AND 7 CAN BE MADE BY BOLTING THE PURLINS TO THE WALL AND GROUTING THEM SOLID INTO THE WALL. SEE THE ATTACHED DETAILS. THIS WILL REQUIRE FIELD DRILLING THE PURLINS, GROUTING THE CORE BELOW THE PURLIN, INSTALLING AN ANCHOR BOLT AND FINALLY GROUTING THE ENTIRE CROSS SECTION INTO THE POCKET. AMERICAN BUILDINGS' DESIGNER BILL PERRY HAS STATED OVER THE PHONE THAT THE PURLINS WILL BE ABLE TO TAKE THE LOAD. WE MUST OBTAIN WRITTEN APPROVAL OF OUR PROPOSED DETAIL. A MORE COMPLICATED CONNECTION SCHEME WOULD BE REQUIRED IF THE PURLINS ARE NOT CONNECTED, (SEE NOTE 3).

ONCE ~~[illegible]~~ THE PURLINS ARE CONNECTED TO THE WALL, HOWEVER, ALL ROOF LIVE LOAD WILL BE

SUPPORTED BY THE WALL, NOT THE FRAME.*

THE WALLS AND THEIR FOUNDATIONS HAVE BEEN CHECKED FOR FULL VERTICAL ROOF LIVE LOAD. THE FOUNDATIONS ARE EASILY CAPABLE. THE WALLS WILL SUPPORT THE LOAD AS LONG AS THE PURLINS ARE BOLTED TO THE WALL SO AS TO PROVIDE LATERAL SUPPORT. WHERE THE PURLINS ARE NOW DETAILED TO SIT ON TOP OF THE WALL, THE BLOCK SHOULD BE BROUGHT UP TO THE TOP OF THE PURLIN TO ALLOW THE PURLIN TO BE GROUTED INTO THE WALL. THIS WILL AFFECT FLASHING DETAILS.

NOTE THAT IF THE PURLINS ARE NOT TO BE USED FOR LATERAL & LOAD TRANSMISSION, A CLEARANCE MUST BE PROVIDED BELOW THE PURLINS TO ALLOW FOR VERTICAL DEFLECTION OF THE FRAME. OTHERWISE, THE WALL WILL BE LOADED VERTICALLY BY THE PURLINS BUT THE PURLINS WILL NOT PROVIDE NECESSARY LATERAL SUPPORT SINCE THEY ARE NOT CONNECTED SECURELY TO THE WALL. THEREFORE, THE SLENDERNESS RATIO OF THE WALL WILL BE GREATER THAN THE ALLOWABLE.

* SEE ANCHOR BOLT NOTE

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THE PURLINS SHOULD BE ISOLATED FROM THE SOUTH ENDWALL AT FRAME 10 SO THAT ADDITIONAL VERTICAL LOAD IS NOT APPLIED TO THE BEAM OVER THE 34 FOOT WIDE DOOR. WHILE THIS BEAM ACTUALLY HAS SUFFICIENT EXCESS CAPACITY TO SUPPORT ROOF LIVE LOAD, IT DOES NOT SEEM REASONABLE TO ADD THIS LOAD NOW BECAUSE OF THE COMPLEXITY OF THE LOADING ALREADY ON THE BEAM.

THEREFORE, CLEARANCE MUST BE PROVIDED BELOW THE PURLINS TO ALLOW THE FRAME TO SUPPORT THE ROOF BY DEFLECTING. UNLESS AMERICAN BUILDINGS CAN GIVE US MORE PRECISE VALUES, A CLEARANCE OF 3 INCHES SHOULD BE PROVIDED UNDER EACH PURLIN.

TO PROVIDE A CONNECTION BETWEEN FRAME 10 AND THE ENDWALL, TO TRANSMIT LATERAL LOAD, THE RAFTER SHOULD BE BOLTED TO THE WALL. SLOTTED HOLES WILL BE PROVIDED TO ALLOW VERTICAL MOVEMENT. SEE DETAILS.

IF WE TRY TO RELY ON THE ENDWALL COLUMNS, PROBLEMS COULD DEVELOP WHEN WIND LOADS THE EAST SIDEWALL. IN THAT CASE, ONLY TWO TALL, NARROW PIERS ARE AVAILABLE IN THE WALL. VERTICAL REINFORCING WOULD HAVE TO BE ADDED AND GROUTED INTO THE FOUNDATION WALL. ALSO THE CLIP ANGLES CONNECTING RAFTER AND COLUMNS WOULD HAVE TO BE STRENGTHENED OR REPLACED.

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WIND AGAINST EACH ENDWALL IS DISTRIBUTED BY THE WALL TO THE ENDWALL COLUMNS, THE FOUNDATION AND THE SIDEWALLS AT THE BUILDING CORNERS. LOAD TRANSMITTED BY THE COLUMNS TO THE ROOF IS TRANSMITTED TO THE PORTAL FRAMES WHICH ARE ATTACHED TO THE SIDEWALL COLUMNS. THE SIDEWALL COLUMNS ARE ANCHORED TO THE SIDEWALLS AT THE OUTER FLANGES. THESE COLUMNS WILL TRANSMIT NEARLY ALL LOAD TO THE SIDEWALLS, DEPENDING ON THE RIGIDITY OF THE ANCHORS AND THEIR ABILITY TO REMAIN EMBEDDED IN THE WALL UNDER THIS LATERAL LOAD. ?

THE DEFLECTIONS OF THE PORTAL FRAMES REPORTED TO US BY AMERICAN BUILDINGS, (ASSUMING NO LOAD TRANSMITTED TO THE WALLS), SHOW THAT THESE FRAMES ARE FLEXIBLE ENOUGH SUCH THAT VIRTUALLY ALL OF THE LOAD WILL BE RESISTED BY THE SIDEWALLS AND NOT BY THE PORTAL FRAMES AS LONG AS THE COLUMN ANCHORS ARE RIGID?. (SEE "ANCHOR NOTE") IF THEY ARE NOT RIGID THEY MUST BE ABLE TO DEFLECT OR ALLOW FRAME MOVEMENT WITHOUT FAILING, (SEE "ANCHOR NOTE").