Design

# Multi-level benchwork

## How to plan a multiple-level railroad/**Jack Burgess**

Considerable trackplanning philosophy lately has emphasized a departure from the "spaghetti-bowl" designs of several years ago to more conservative, realistic plans. This shift has led to the use of multiple-level benchwork in order to provide a long main line, such as on my own Yosemite Valley Railroad as presented in the November, 1980, RMC. While multiple levels seem to be an obvious answer to these goals, the construction of multi-level layouts presents some interesting problems.

The simple glued and screwed cantilevered arrangement shown in Fig. 1 is sufficient for around the room multi-level layouts where the width of the upper level is narrow (probably less than 6-8″). As the layout width of this upper level increases, the number of supports for this level must be increased (i.e., the distance between vertical supports reduced) or the joint reinforced by the use of right-angle shelf brackets or some other support. As this upper level reaches 12″ or more, even more vertical supports don't help significantly. This is because the torque which works against this joint is proportional to the force(weight) loading the beam (load $L$ in Fig. 2) and the moment arm (length $d$ in Fig. 2). Increasing either or both of these factors will increase the torque.

The simplest way to counteract the torque is to create a basic truss by adding a support arm from below (in compression) or from above (in tension) as in Fig. 3.

A support used from below is not too practical. However, a tension-type support can easily be incorporated if the upper levels represent mountainous terrain by revising the truss member to become a profile board (Fig. 4).

My own Yosemite Valley Railroad uses these 3/4″ plywood profile boards attached to 2″×2″ uprights on approximately 36-38″ centers; the profile boards cantilever out as much as 18″ without problems and with freestanding uprights. In fact, wall braces shown as optional in Fig. 4 are used at only three locations (one per wall; none on garage door side) to prevent overall layout shifting, rather than to add to the upper level's stability.

Because of the need to minimize the thickness of the upper level (to avoid infringing needlessly on the lower level), I cut the profile boards to accept the roadbed and frontboard as shown in Fig. 5. To follow this example, one must be very careful about grades for the upper level; lowering the level later to reduce an excessive grade is very difficult and frustrating. A certain amount of measurement and calculation are also needed with this pattern if the bottom of the upper level frontboard is to remain level around the room. The simplest procedure seemed to be to temporarily clamp the upper level roadbed in place and, with an oversize profile board clamped under it, mark the horizontal location of the roadbed. After the roadbed notch is cut out, reclamp the profile board in place, this time in the correct vertical relationship with the roadbed. Now mark the location of the bottom of the frontboard and the profile and do the final cutting. To provide additional rigidity to the upper level and as a support for the frontboard, I also connected all of the profile boards at their front edges with a 1″×2″ crossbrace. These braces are also shown in Fig. 5.

Providing for cantilevered upper-level benchwork in peninsula areas can be even simpler and can also be applied to "flat-land" scenery situations. Here, the torque on the cantilevered end of the support can be overcome by a "back-tie" as shown in Fig. 6. This brace prevents the horizontal support from rotating around the upright. If the peninsula is double-sided, the "back-tie" can be eliminated since the upright for one side acts as the "back-tie" for the opposite side. See Fig. 7 ⊂

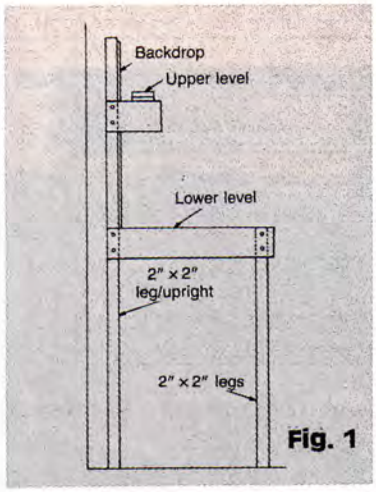

Fig. 1

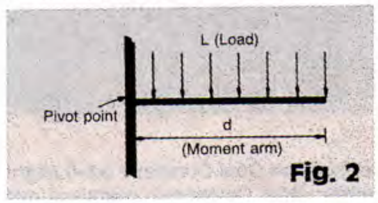

Fig. 2

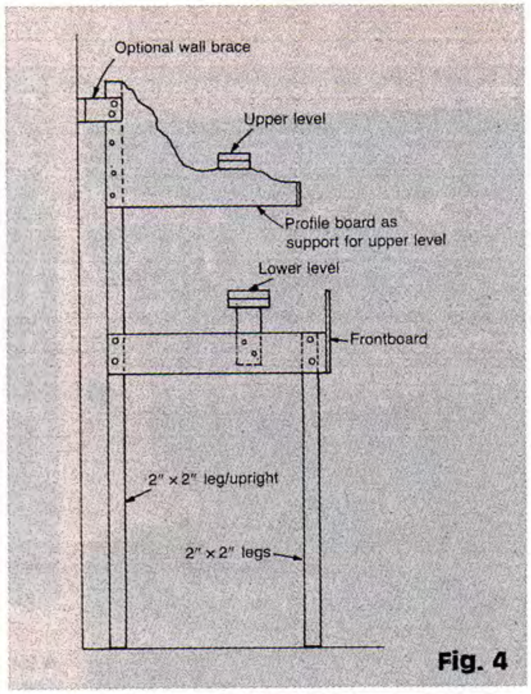

Fig. 4

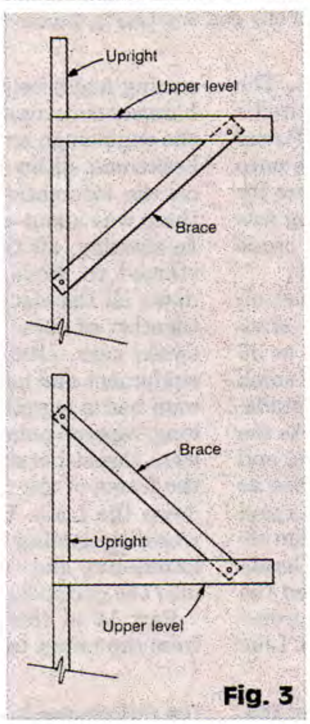

Fig. 3

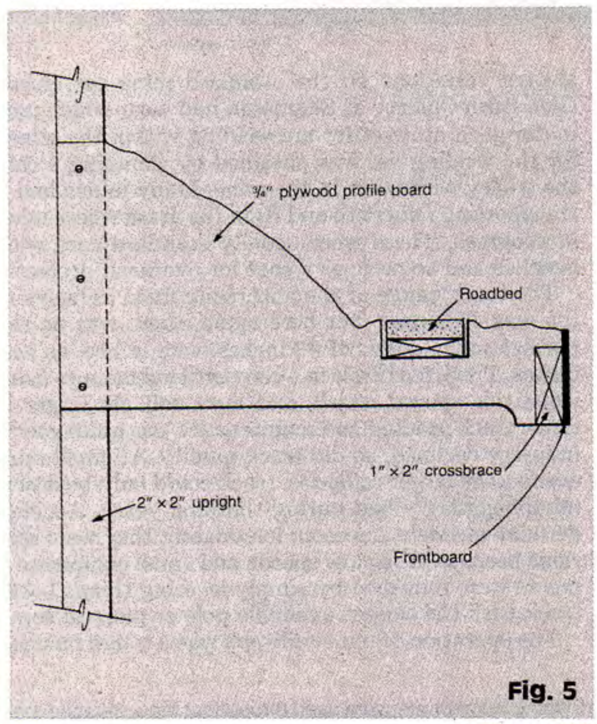

Fig. 5

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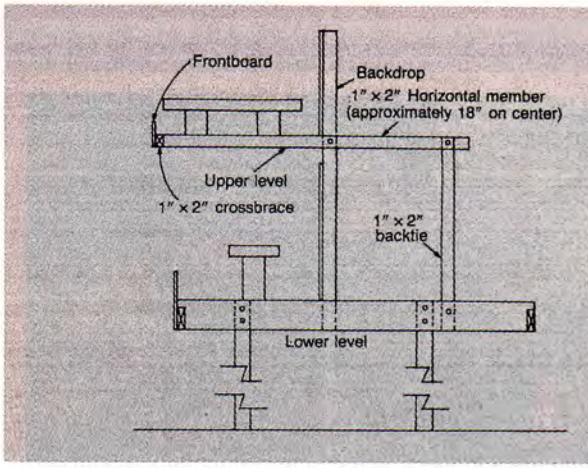

Fig. 6

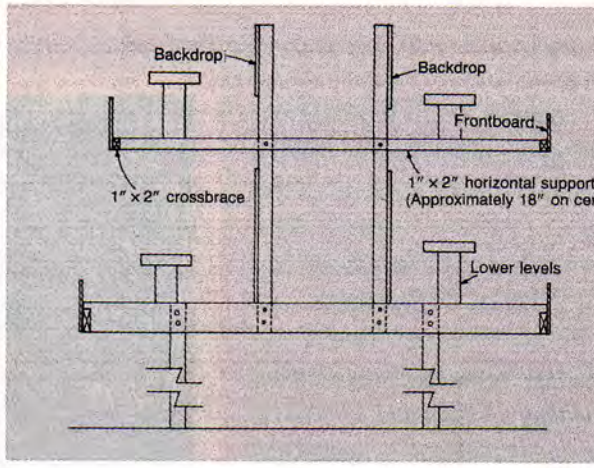

Fig. 7

Multilevel layouts are interesting design challenges. The problem of accommodating needed grade sections to reach upper levels by hidden spiral helix sections or otherwise hidden trackage was briefly discussed in the November 1980 RMC. Other problems are worth repeating.

**Yard locations:** Unless future operations will be limited to a single engineer, yard locations and switching areas must be carefully located. Stacking two yard or switching areas vertically in the same area can lead to more than one operator trying to occupy the same space at the same time. Two operators jockeying for position to reach turnout controls and keeping track of walk-around control cables can be likened to square dances late on Saturday night. Yards and switching areas should therefore be horizontally separated to avoid conflicting floor space needs.

**Separation of levels:** Selection of a minimum standard for vertical separation between levels is a critical decision and is dependent upon several factors. These factors include height of the upper level, viewing height, viewing distance, height of the upper level front board and the width of the upper level. The general goal will probably be to insure that a viewer will be able to see all of the lower level as far back as the base of the backdrop. It can thus be seen that, for an assumed viewing height and distance, increasing the upper level width or the height of the front board, or lowering the upper level, will each require increasing the vertical separation between the levels to maintain this goal.

The relationship of these factors is shown in Fig. A and by the following formulas:

$$H_1 = V_H - \frac{(V_H - H_2 + F_H)(L_W + V_D)}{V_D}$$

and

$S = H_2 - H_1$

where

$H_1$ = Height of lower level
$V_H$ = Viewing height
$H_2$ = Height of upper level
$F_H$ = Front board height
$L_W$ = Upper layout width
$V_D$ = Viewing distance
S = Minimum vertical separation

## Additional design criteria

An average viewing distance can be assumed to be approximately 14". For various combinations of viewing height and upper level layout height, the minimum separation to enable a viewer to see all of a lower level for upper level widths of 12", 18" and 24" are shown in the following table:

| Layout width | | Separation 12" | 18" | 24" |
|---|---|---|---|---|
| VH= 61 | ,H2= 52 | * | 18 | 24 |
| VH= 61 | ,H2= 54 | * | 16 | 20 |
| VH= 61 | ,H2= 56 | * | * | 17 |
| VH= 61 | ,H2= 58 | * | * | * |
| VH= 61 | ,H2= 60 | * | * | * |
| VH= 63 | ,H2= 52 | 15 | 21 | 27 |
| VH= 63 | ,H2= 54 | * | 18 | 24 |
| VH= 63 | ,H2= 56 | * | 16 | 20 |
| VH= 63 | ,H2= 58 | * | * | 17 |
| VH= 63 | ,H2= 60 | * | * | * |
| VH= 65 | ,H2= 52 | 17 | 24 | 30 |
| VH= 65 | ,H2= 54 | 15 | 21 | 27 |
| VH= 65 | ,H2= 56 | * | 18 | 24 |
| VH= 65 | ,H2= 58 | * | 16 | 20 |
| VH= 65 | ,H2= 60 | * | * | 17 |
| VH= 67 | ,H2= 52 | 18 | 26 | 34 |
| VH= 67 | ,H2= 54 | 17 | 24 | 30 |
| VH= 67 | ,H2= 56 | 15 | 21 | 27 |
| VH= 67 | ,H2= 58 | * | 18 | 24 |
| VH= 67 | ,H2= 60 | * | 16 | 20 |

VH: average viewing height
*Use 14" minimum

As shown in this table, a separation (S) of approximately 16" will be needed for a viewing height of 67" (eye level for a 6'-0" individual) and an upper-level elevation of 60" from the floor if the upper-level layout width is 18" or less. While I originally designed my own layout with a separation of 16", this choice was compromised to 14" during construction. From my own sense of balance, I feel that 14" is the minimum; any less encroaches on the lower level too much. Therefore, combinations in the above table which produce results of less than 14" separation are shown with an asterisk. Of course, a design goal can be selected which is less than that shown in the table, i.e., a separation of 16" with $V_H = 65"$ and $H_2 = 58"$, and an upper-level width of 24" or greater. However, as shown in the table, this combination will produce a situation where the bottom level is not viewable in its entirety.

**Points of interest:** Since limiting an upper level to a single, minimum width can be visually unexciting, there will probably be locations where the viewing of the lower level will be hampered. This apparent handicap can be utilized as an advantage through proper positioning of major points of interest. A mainline can be visually lengthened by separating the points of interest (detailed areas, passing sidings with trackside details, towns, interestingly sceniked areas, etc.) with areas of mundane, commonplace scenery. Utilize this tool by narrowing the upper level (and thus creating a separation section) above interesting areas on the lower level and vice versa. Narrowing the upper level will open up the view of the lower level below it and thus draw attention to it. Widening the upper level and reducing the width of the lower level will bring it out for greater interest.

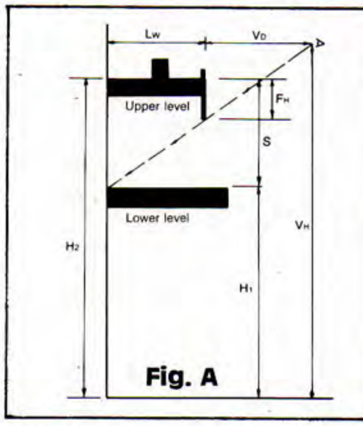

Fig. A

**Grades and scenery:** Vertical separation of levels is generally thought of in terms of measurement of the separation *S* on Fig. A. However, the actual separation should be measured from the roadbed. Thus, unless the vertical separation between levels is increased, the height of the lower roadbed above the benchwork must be minimized. Likewise, scenery on the lower level must not extend too high above the base layout level to avoid encroaching on the separation between levels. Remember, too, that extending scenery below the track level on the upper level (such as a creek, rivers, etc.) is limited. Switch machines, etc. must also have a low-profile on the upper level.