Replacing a Load Bearing Wall with a Beam

Sage Cawthern
Faculty Advisor: Dr. Raymond Cook
Department of Civil and Environmental Engineering, University of New Hampshire, Durham, NH 03824

Introduction

Headers are framing members which span over a wall opening and transfer the structural loads from above to bearing members at either end of the beam. Their job is to maintain the structural integrity of the wall and elements above. In renovations, when a load-bearing wall is removed or a door opening is widened, a new header is required to carry the loads from above.

There are many header options available to the designer, but few professionals are familiar with all the available options. As a solution, a design-aid was created to take a range of materials into account. These include dimensional lumber, laminated strand lumber (LSL), laminated veneer lumber (LVL), parallel strand lumber (PSL), glued laminated timber (glulam), steel W-shapes, steel M-shapes, and steel S-shapes.

Headers

Header material selection is based on the framing structure, span of the opening, budget, and the magnitude of the loads carried.

In wood framed structures, wood is the traditional material of choice because of its easy integration, but other materials may work better or result in lower costs. Engineered lumber (glulam, LVL, LSL, and PSL), offers wood options that have higher capacities than two-by dimensional lumber headers.

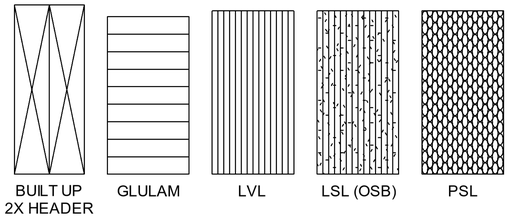

Figure 1: Wood Header Options

Steel headers may be the best choice when long spans are needed or there are greater loads, especially when the header height is limited. Figure 2 shows the typical shapes that are used for these applications.

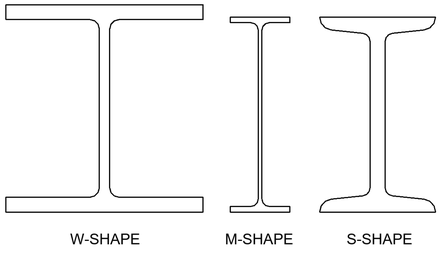

Figure 2: Steel Lintel Options

Example

Using ten interconnected spreadsheets, the design-aid returns header options for specific geometry and loading. Figure 3 shows a scenario where a six-foot-long header is being introduced to a load bearing wall. The information can be inputted such as in Table 1. The design options for the specific header are returned in Table 2.

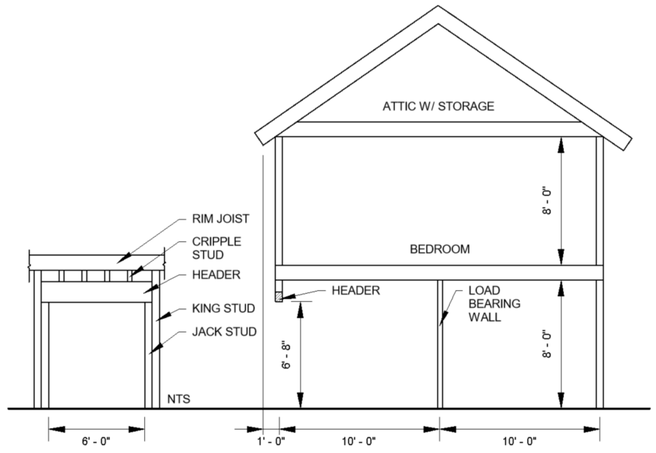

Figure 3: Header Example

Table 1: Input Table

Input				
Item		**Variable**	**Value**	**Units**
Geometry	Clear Span	l_clr	6	ft
	Height	ht	6.667	ft
	Stud Sizes	stud	2x6	
Loading	Attic Live Load	L_attic	20	psf
	Attic Dead Load	D_attic	10	psf
	Attic Tributary Width	TW_attic	10	ft
	Room Live Load	L_room	30	psf
	Room Dead Load	D_room	10	
	Room Tributary Width	TW_room	5	ft
	Weight of Wall above	D_wall	10	psf
	Height of Wall above	H_wall	9.333	ft
	Roof Live Load	L_roof	5	psf
	Roof Dead Load	D_roof	15	psf
	Roof Snow Load	P_SL	42.4	psf
	Roof Rain Load	P_RL	0	psf
	Tributary Width	TW_roof	12.3	ft
	Additional Live Load	L_addl	0	psf
	Tributary Width	TW_Laddl	0	ft
	Additional Dead Load	D_addl	0	psf
	Tributary Width	TW_Daddl	0	ft
2x Wood	Southern Pine Y/N for adjustment		No	
	Species		Spruce_Pine_Fir	
	Commercial Grade		Spruce-Pine-Fir No. 1/No. 2	
	Use		Slct Structural or No.1 thru 3 or Btr	
GluLam	Type		Hardwood	
	Species		E-Rated Hardwoods	
	Species Short		ERH	
	Stress Class		16F-E2	
Steel	Yield Strength	F_y	50	ksi

Table 2: Output Table

Header Solutions		Deflection Check					
Header Nominal or Actual Units Specific to Material	**Board Foot of Jack Studs and Header**	**Live Load Deflection** in	**Dead & Live Load Deflection** in	**Allowable Deflection Limits**			
				L/180	**L/240**	**L/360**	**L/480**
2x Wood							
2 Jack Stud(s) each side with (2) 2x12 Headers	25.46	0.057	0.188	0.417	0.313	0.208	0.156
2 Jack Stud(s) each side with (3) 2x10 Headers	29.79	0.102	0.337	0.417	0.313	0.208	0.156
Timberstrand LSL							
1 Jack Stud(s), each side with a Grade 1.3E 3.5x11.875 Timberstrand LSL Header	25.12	0.027	0.089	0.400	0.300	0.200	0.150
1 Jack Stud(s), each side with a Grade 1.3E 3.5x14 Timberstrand LSL Header	28.79	0.018	0.060	0.400	0.300	0.200	0.150
Microllam LVL							
2 Jack Stud(s), each side with a 1.75x11.25 Microllam LVL Header	18.13	0.043	0.143	0.410	0.307	0.205	0.154
2 Jack Stud(s), each side with a 1.75x11.875 Microllam LVL Header	18.63	0.038	0.125	0.410	0.307	0.205	0.154
Parallem PSL							
1 Jack Stud(s), each side with a 5.25x11.25 Parallam PSL Header	34.09	0.014	0.047	0.408	0.306	0.204	0.153
1 Jack Stud(s), each side with a 5.25x11.875 Parallam PSL Header	35.72	0.012	0.041	0.408	0.306	0.204	0.153
Glulam							
1 Jack Stud(s), each side with a 5.125x10.5 GluLam Header	31.45	0.02	0.06	0.41	0.31	0.20	0.15
1 Jack Stud(s), each side with a 5.125x12 GluLam Header	35.29	0.01	0.04	0.41	0.31	0.20	0.15
Steel							
Header	**Total Weight** lbs	**Live Load Deflection** in	**Dead & Live Load Deflection** in	**Allowable Deflection Limits**			
				L/180	**L/240**	**L/360**	**L/480**
W4X13 Header	78	0.037	0.121	0.400	0.300	0.200	0.150
W5X16 Header	96	0.019	0.064	0.400	0.300	0.200	0.150
M4X6 Header	36	0.088	0.290	0.400	0.300	0.200	0.150
M5X18.9 Header	113.4	0.017	0.057	0.400	0.300	0.200	0.150
S4X7.7 Header	46.2	0.068	0.226	0.400	0.300	0.200	0.150
S4X9.5 Header	57	0.061	0.202	0.400	0.300	0.200	0.150

References

American Wood Council. (2017, November 16). National Design Specification for Wood Construction with Commentary. NDS.
American Institute of Steel Construction. (June 2019). Steel Construction Manual. AISC 15th Edition.
American Society of Civil Engineers. (2010). Minimum Design Loads for Buildings and Other Structures. ASCE 7-10.
Ashby Lumber. (2021). Engineered Products. https://store.ashbylumber.com/
HomeGuide. (2021). Structural Steel Prices. https://homeguide.com/costs/steel-beam-cost
Menards. (2021). Trusses, I-Joists & Engineered Lumer. https://www.menards.com/main/building-materials/trusses-i-joists-engineered-lumber/c-5657.htm
Robinson Manufacturing Limited. (2021). Gullam Beams. https://rmuk.co.uk/glulam-beams/
Weyerhaeuser. (June 2019). Trus Joist Beam, Header, and Column Specifier's Guide. #TJ-9000. Weyerhaeuser NR Company.

Results

The results obtained with the use of the design-aid allow for a better designed structure that is more efficient and cost effective. The board foot and weight outputs can be beneficial when estimating the cost of a specific header. An estimate of the current costs of each header option is shown in Table 3.

Table 3: Costs

Header	Approximate Cost per header
(2) 2x12	$41.00
(3) 2x10	$45.00
3.5x11.875 LSL	$54.00
3.5x14 LSL	$63.00
1.75 x 11.25 Microllam LVL	$46.00
1.75x11.875 Microllam LVL	$48.00
5.25x11.25 Parallam PSL	$145.00
5.25x11.875 Parallam PSL	$150.00
5.125x10.5 Glulam	$83.00
5.125x12 Glulam	$88.00
W4x13	$98.00
W5x16	$120.00
M4x6	$45.00
M5x18.9	$142.00
S4x7.7	$58.00
S4x9.5	$72.00

Conclusions

When replacing a load-bearing wall with a header, an engineer has many different material options. This spreadsheet tool allows the designer to quickly compare potential headers to arrive at the best solution for the situation.

For the six-foot header with the loading as outlined in Table 1, dimensional lumber may be the best option if header height is not limited. This is confirmed with the cost estimate above. With a longer span or larger loads, the best option would shift towards engineered lumber or steel, as these have greater capacities.

Acknowledgements

I would like to thank my advisor, Professor Raymond Cook for his time, expertise and feedback on my thesis work.

Additionally, I would like to thank both Prof. Cook and Prof. Bell for their instruction in Timber Design and Structural Design in Steel, respectively.