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Increasing Design-Build Project Performance

..through progressive steel joist and metal decking design

Flexible to the Finish

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Learning objectives

After viewing this presentation, you will be able to:

- Recognize and understand ways to improve the design-build steel construction process through progressive steel joist and metal decking design.
- Know the range of overt and covert costs to a design-build project as related to the steel joist and steel deck phase of building design.
- Know the fundamentals of engineering for total-project cost control, from tonnage reduction to a related chain reaction of costs.
- Know the current range of steel construction materials and methods, including special profile joists, tension-controlled steel joist design, and building-information modeling (BIM).

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This course will provide design-build steel construction practitioners a deeper set of insights regarding steel joist and metal decking design. This includes ways to improve the RFI process, and ways to reduce a range of traditionally tolerated project costs. We will also demonstrate some pro’s and con’s regarding digital steel joist design and BIM-based project development. And we will review several trends in steel construction materials and methods.

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Course outline

- Recognizing Joist-Related Total Project Performance
- Engineering for Total Project Cost Prevention
  - Tonnage reduction
  - MEP clash prevention
  - Metal decking design considerations
- Special Profile Joists
- Tension-Controlled Steel Joist Design
- BIM joist advantages from an owner's point of view

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We will address overall design-build project performance from the perspective of improved steel joist design and metal decking design. We will cover best engineering practices, cost-accountable architectural achievement, and the importance of taking the project owner's point of view when designing the steel package. We will review the use of special profile joists, and the emergence of tension-controlled steel joist design. Then we will wrap up with a summary of BIM-based steel project collaboration from the owner's point of view.

The design-build approach has become a much more dominant method of construction in recent years. According to the Design Build Institute of America, about 40% of non-residential construction is being done using the design-build approach. But what more do we need to know about design-build steel construction?

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Survey Findings

D-B wants preferred partners.

60% of firms said they participated in design-build projects as a preferred partner, rather than by way of lowest qualified bid.

Source: Survey of Design-Build Professionals
Centrifuge Research, April 2013

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A recent survey of design-build professionals explored some fundamental precepts of the design-build approach. The survey found that the professionals involved in the design-build approach tended to value preferred partner relationships. On a steel building project, this preference can extend from top to bottom, from the builder to the joist-and-deck company.

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Survey Findings

D-Bs often use a preferred joist supplier.

30% said they tended to work with a preferred steel joist suppler.

57% said they hire the steel joist supplier directly and before the steel fabricator at least sometimes.

Source: Survey of Design-Build Professionals
Centrifuge Research, April 2013

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The survey found that many design-build firms are calling upon joist and deck companies directly. They are doing this before selecting a steel fabricator.

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Survey Findings

Incomplete drawings still a problem.

22% acknowledged the drawings for their design-build projects were only sometimes complete, another 10% said they were seldom complete.

Source: Survey of Design-Build Professionals
Centrifuge Research, April 2013

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The survey verified that a serious constraint even to the design-build approach, is the lack of completed drawings. So a key strategy is to bring the joist and deck company in early so as to shorten the RFI process. This is especially helpful on projects with high percentages of joist and deck.

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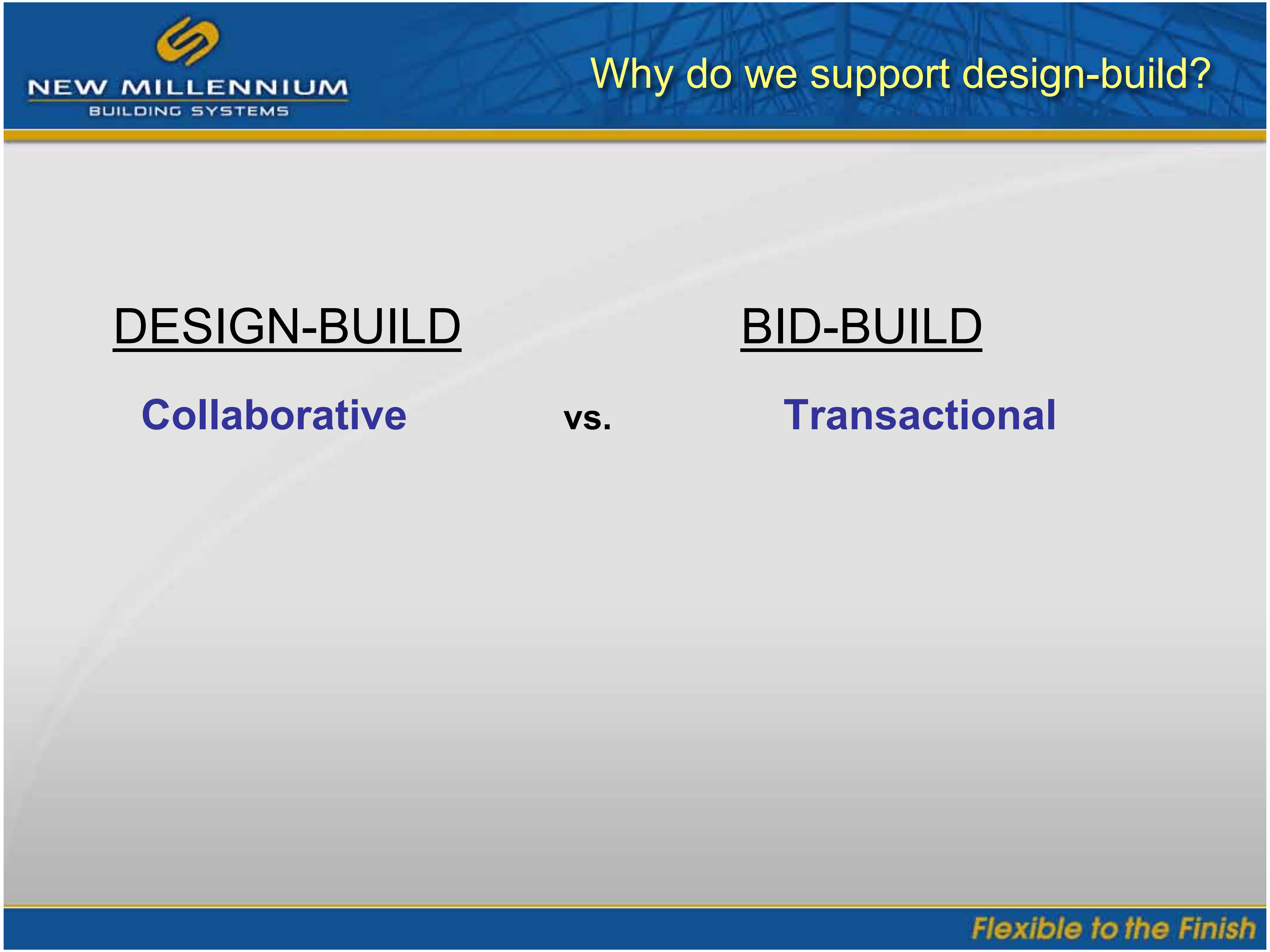
Top 2 reasons for using a preferred joist supplier:

1) Early design collaboration
2) Reduce total project costs

Source: Survey of Design-Build Professionals
Centrifuge Research, April 2013

When design-build firms were asked why else they brought a joist and deck company in early, these were the top two reasons they gave. Design collaboration and cost reductions. These were the same reasons given for hiring a joist company directly, rather than leave the decision to a steel fabricator based on a low bid arrangement.



Here's what we have been able to prove based on our involvement in design-build. When we are brought in early as part of a design-build project, expectations are unlike a traditional bid-build approach. From the start, the design-build approach fosters collaboration. Communication is much less transactional.

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Why do we support design-build?

DESIGN-BUILD		BID-BUILD
Collaborative		Transactional
Create best design	**vs.**	**Meet std. chart specs**

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The joist and deck company is encouraged to think creatively about design engineering from the stand-point of cost reduction. The objective is not to meet an existing specification, which is often based on broad standard load tables and product designations.

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Why do we support design-build?

DESIGN-BUILD		BID-BUILD
Collaborative		Transactional
Create best design		Meet std. chart specs
Focused on outcomes	**vs.**	**Focused on RFIs**

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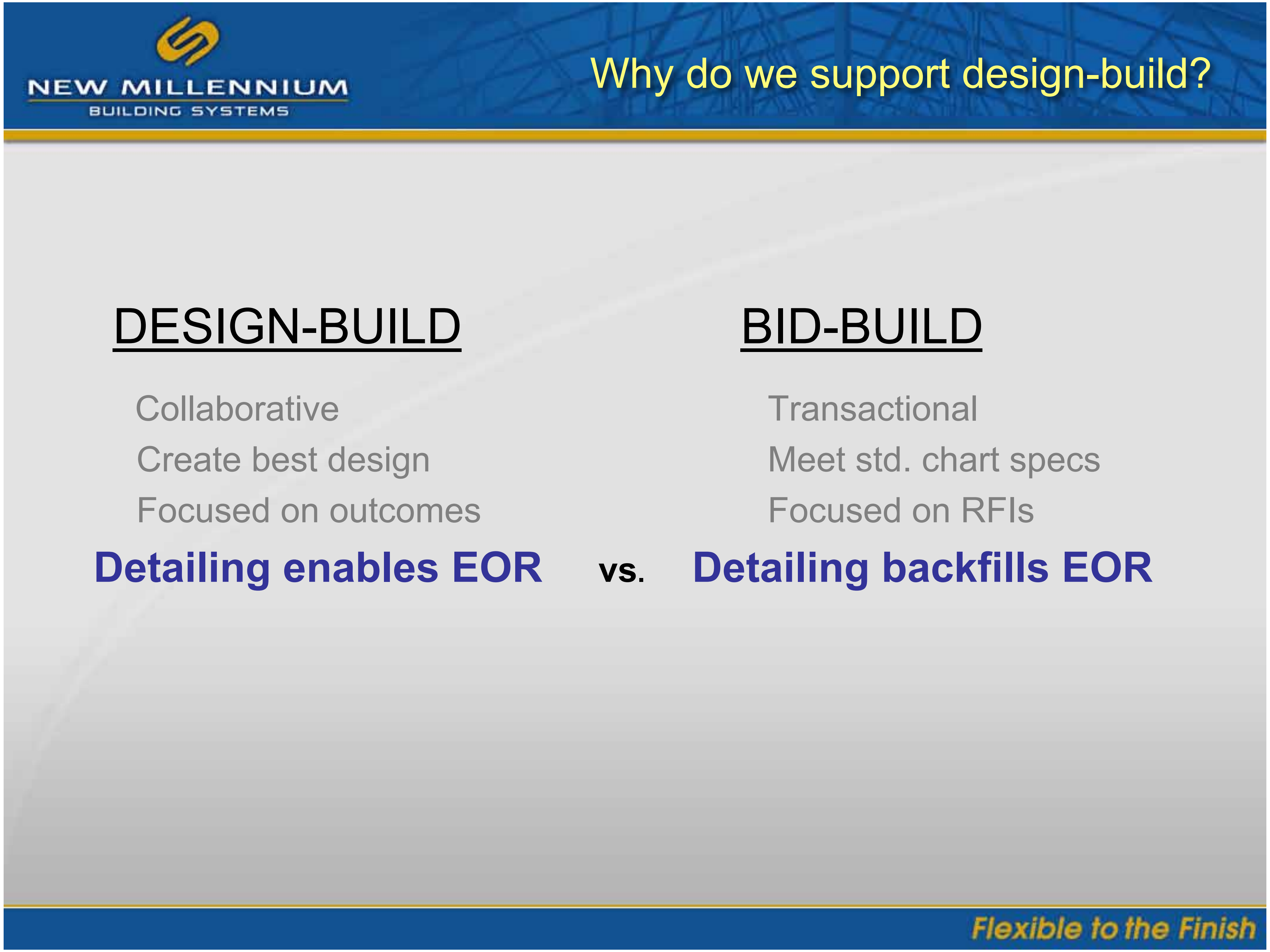
On a design-build project, the joist and deck supplier can focus on design performance and outcomes. Unlike bid-build, the supplier's role and value to the project is not to bulldog Requests for Information. On a design-build project, RFI's are quickly addressed and do not hold the project up.



Detailing can often create delays that are tolerated on the bid-build side. But on a design-build project, the joist and deck company can complete the detailing for the EOR to integrate into their plan, instead of trying to backfill. Detailing early on provides for a much more constructive and efficient flow.

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Why do we support design-build?

DESIGN-BUILD	BID-BUILD
Collaborative	Transactional
Create best design	Meet std. chart specs
Focused on outcomes	Focused on RFIs
Detailing enables EOR	Detailing backfills EOR

Early owner/EOR input **vs.** **Belated owner/EOR review**

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Starting early in the project, the owner and EOR can review and contribute to the plan at every critical decision point, rather than try to do so after the fact.

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Why do we support design-build?

DESIGN-BUILD		BID-BUILD
Collaborative		Transactional
Create best design		Meet std. chart specs
Focused on outcomes		Focused on RFIs
Detailing enables EOR		Detailing backfills EOR
Early owner/EOR input		Belated owner/EOR input
End goal = project success	**vs.**	**End goal = material delivery**

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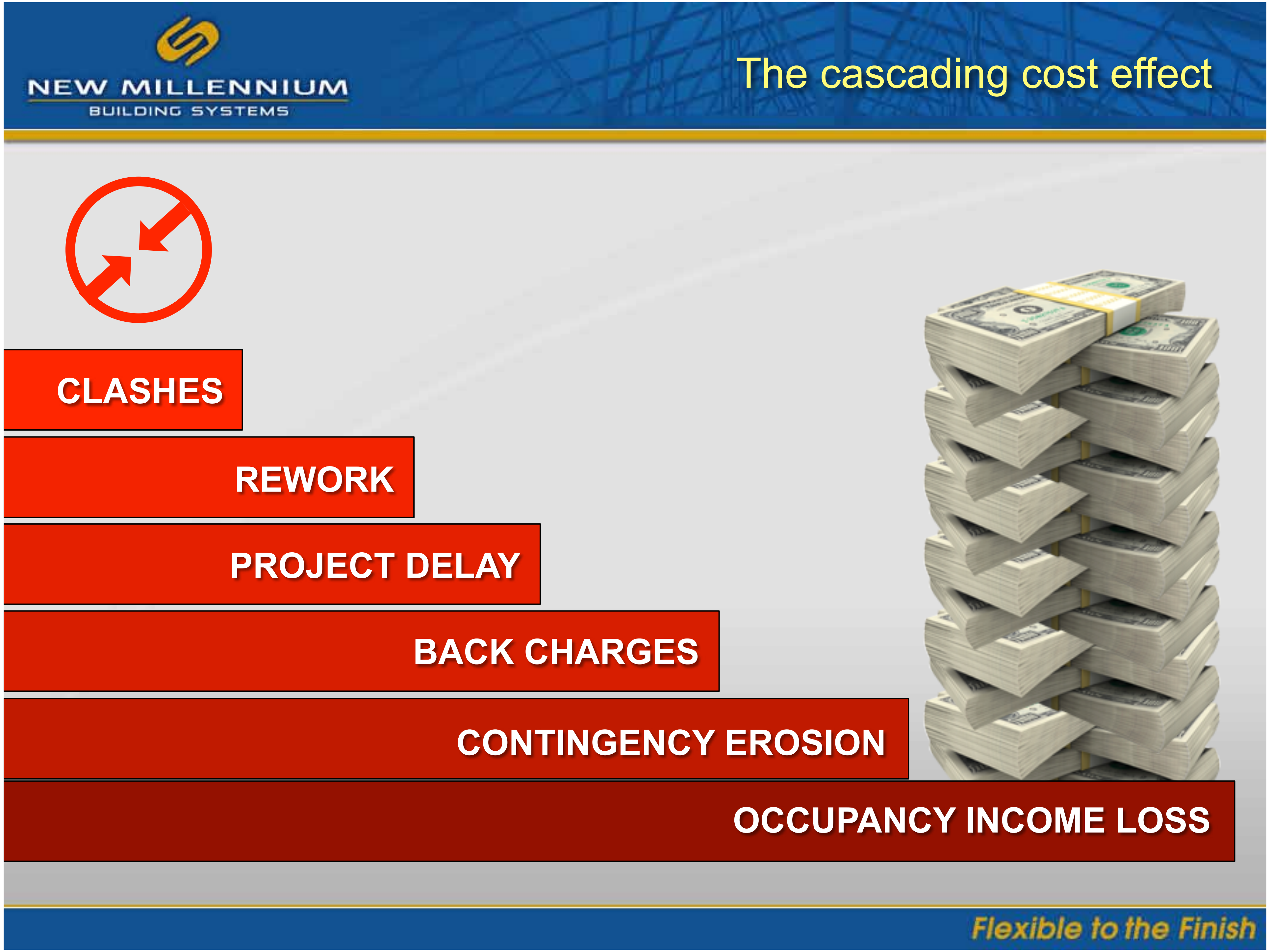
The bottom line – on a design-build project the joist and deck company has the opportunity to bring its engineering capabilities forward. For them, the end goal of the design-build approach is more aligned with project success. Whereas on a bid-build project, the end goal for a joist company can often be material delivery.

Total Project Performance

as impacted by steel joist design and supply



Our own research into steel construction has documented a range of costs that can be generated early in a project. The structural steel phase of a project can have enormous cost implications. As owners look more carefully at this phase, they are seeing a cascading cost effect. They see clashes and rework, which result in project delays and back charges. They see the project burning through contingency fees. And a delayed move-in can cause huge losses to the owner whether by way of lost retail revenues or lost occupancy income.

Proactive, early design engineering is essential to cost prevention. Every ton of steel removed can cut from $800 to $1,000 dollars out of a project. That's just for material cost. There are related costs.

The related costs include warehousing the right amount of steel for a job, reducing down to the right number of manufacturing hours, and so the right number of delivery trucks. Which means less costs on site for steel handling and erection labor. All of which also translates into a shorter project timeline, because the structural steel package comes early in a project ahead of most everything else.

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Engineered Cost Reduction

Areas of focus:

- **Reduce tonnage**
- **Reduce related chain reaction of costs**
- **Prevent MEP/ on-site clashes**

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Proactive engineering during the steel joist and decking phase can significantly minimize contributions to total-project costs. This can be done by reducing tonnage, optimizing the design, preventing clashes on the erection site, and by carefully staging project delivery.

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Engineered Cost Reduction

Reduce tonnage and chain reaction of costs:

1. **Reorient the framing can save 0.25 lbs./ft. or $0.50 per sq. ft.**

2. **Updated diaphragm load data expedites metal-deck fastening**

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Here are two ways a joist and deck company can reduce tonnage: First, re-orienting the framing can save .25 pounds per foot or 50 cents per square foot. This enables the steel contractor to coordinate with exterior wall contractor and potentially save thousands of linear feet of bent plate. Second, updating the diaphragm load data can cut costs for metal-deck fastening, including the use of lighter deck gauge.

Space joists to maximize deck capacity

ALLOWABLE UNIFORM LOADS

Span Condition	Gage	Allowable Total (Dead + Live) Uniform Load (psf) Center to Center Span (ft. - in.)										Max. Constr. Span (ctr. to ctr.)
		5 - 0	5 - 6	6 - 0	6 - 6	7 - 0	7 - 6	8 - 0	8 - 6	9 - 0	9 - 6	
Single	22	91	71	57	47	40	34	30	27	24	22	5 - 8
	20	111	86	69	56	47	40	35	31	27	25	6 - 7
	18	156	119	94	76	63	53	46	40	35	31	8 - 2
Double	22	107	88	74	63	54	47	42	37	33	30	6 - 8
	20	133	110	92	79	68	59	52	46	41	37	7 - 10
	18	170	140	118	101	87	76	66	59	53	47	9 - 6
Triple	22	133	110	93	79	68	59	50	44	38	34	6 - 9
	20	166	137	115	98	84	70	59	51	45	39	7 - 11
	18	213	176	146	125	107	93	78	67	58	51	9 - 8

FACTORY MUTUAL SPANS

Gage	Max. Ctr. to Ctr. Span (ft.-in.)
22	6 - 0
20	6 - 6
18	7 - 5

6 - 9
7 - 11
9 - 8

Proactive decking design can contribute importantly to the reduction of total project cost. One of the ways to achieve this is by increasing support member spacing. This not only saves steel, but saves on piece count. A smaller piece count means less fabrication and erection time, so cost savings are compounded.

Another way to reduce deck costs on large projects is to specify a special thickness instead of a standard gauge.

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Engineered Cost Reduction

Digital Specification Tools

- Interactive entry fields
- Easier and faster specification
- Guides lowest cost options

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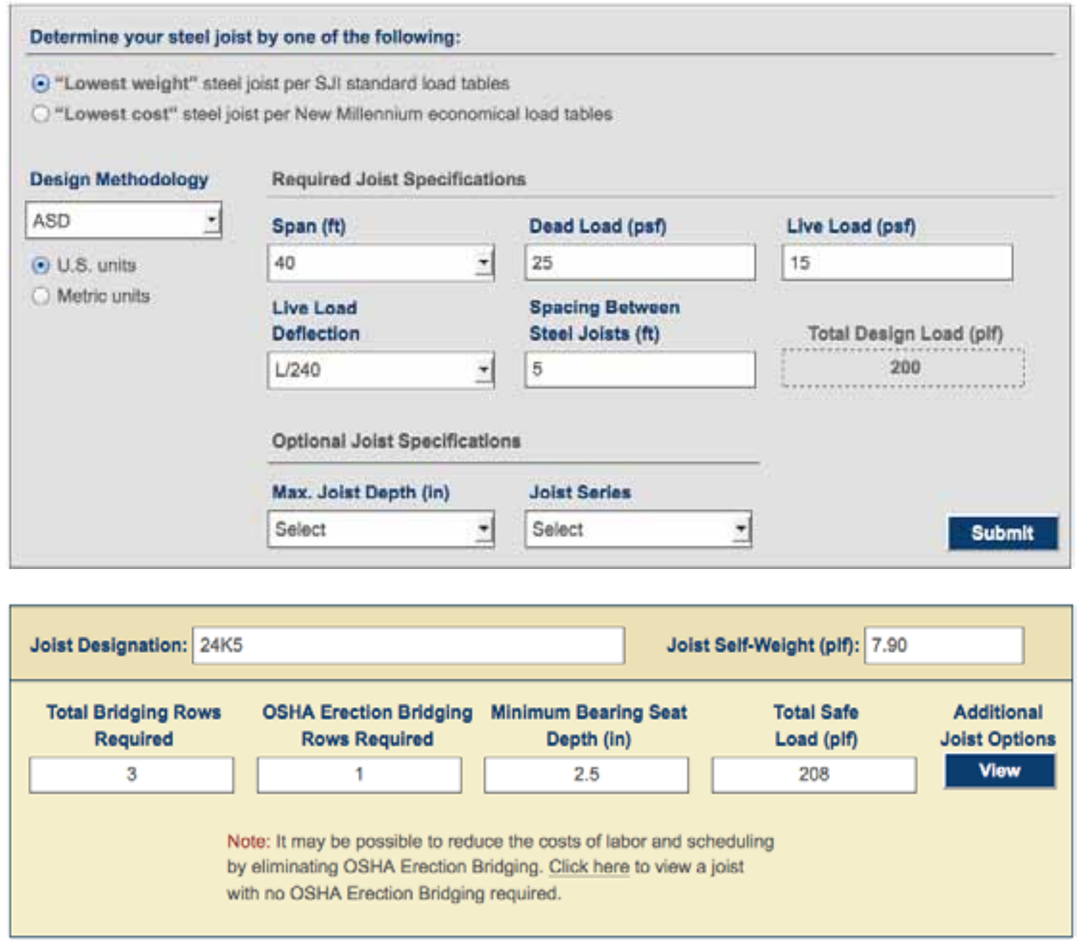
For steel joist and deck, the specification process can be expedited by using the latest database driven lookup tools now on the market. The tools enable a specifier to quickly sort through hundreds of options to arrive at the most cost effective joist and deck designations. The tools are an advanced alternative to referencing catalog charts and load tables.

Engineered Cost Reduction

Select a tool

- K-Series & LH/DLH-Series Joist Tool
- KCS Joist Tool
- Load/Load LH-Series Joist Tool
- Special Profile Gable Joist Tool
- Special Profile Bowstring Joist Tool
- Special Profile Scissor Joist Tool
- Special Profile Arch Joist Tool
- Steel Joist Girder Tool
- Special Profile Gable Joist Tool
- Metal Roof Decking Tool Coming soon!
- Form & Composite Floor Decking Tool Coming soon!



The online tools consist of simple entry fields. Again, the driving reason for this approach is design cost efficiency.

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Results

COST AREAS	POTENTIAL SAVINGS	EXAMPLE ACTUAL $ 1.3M PROJECT
Materials	3% - 10% and up	$124,833 (9.7% of project)
Transportation	5% - 10%	$ 6,726 (0.5% of project)
Product Handling	$10 per ton	$ 1,700 (0.1% of project)
Erection	3% - 10%	$ 60,000 (4.7% of project)
	Subtotal:	$ 193,259

Flexible to the Finish

This is an actual project example. Some of the more obvious cost considerations on a project are Materials, Transportation, Product Handling, and Erection.

Material savings can range from 3% to 20%, but most commonly, between 5% and 10%. On this midsized project, the client saved over $120,000 in materials for a $1.3M project.

Transportation: On average, 17 tons of joists can be loaded on a truck. By reducing tonnage on the project, transportation went from 55 trucks down to 50 trucks. This translated to over $6,000 in savings on transportation.

Product Handling: Based on an estimated $10 per ton cost for loading and unloading, the client saved around $1,700 on the project.

Erection: On the same project, the piece count was reduced by 270 pieces. Based on the approximate cost of $1 per square foot for erection, the project likely netted 10% in erection savings, amounting to around $60,000 in prevented erection labor costs.

This resulted in an overall savings to the project of around $190,000.

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Results – Delaney Warehouse

	Standard Design	Revised Design	SAVINGS
Total Tons	926.77	**848.23 tons**	**78.54 tons** 8.47%
Total Pieces	1841	1571 Pieces	**270 pieces** 14.66%
Total Cost	$1,282,000	$1,157,117	$124,883 9.74%

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On many projects, 1% to 10% of the joist costs can be eliminated. On this midsized warehouse project, joist materials were reduced by spacing the joists properly. The more cost-effective design resulted in less overall tonnage and a lower piece count that resulted in a $124,883 savings on what initially was a $1,282,000 project. This did NOT include the related savings for shipping, handling, storage and erection.

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Results – Cooper Tire

RESULTS

1351.25 tons	→	1251.29 tons
$1,491,632	→	$1,405,266

SAVINGS

99.96 tons	(7.4%)
$86,366	(5.8%)

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Increasing the girder depths on this project resulted in an $86,000 savings to the project. Savings vary and may not match tonnage savings, due to nominal increases in labor and delivery.

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Results – Steel Decking Project

Deck Gauge and Cost Calculation

Example: Roof project in Shepherdsville, KY
6,056 squares of deck, specified painted 22ga
Total weight: 488 tons

Potential cost and ton savings of 23ga vs. 22ga
Gravity load capacity: 25 psf total
23ga allowable for 3-span @ 5’ -6 5/8”

Diaphragm strength req’d	Ga	Pattern
Interior: 325 p/f	22	36/5 - 5 sidelaps
Edges: 464 p/f	22	36/7 - 8 sidelaps
Interior: 325 p/f	23	36/4 - 4 sidelaps
Edges: 464 p/f	23	36/5 - 6 sidelaps

Total weight and cost savings for 23ga:
Deck: *8%*
Joist/deck package: *2%*

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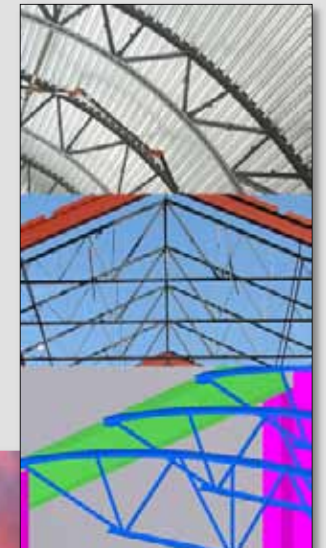
This deck project in Kentucky called for over 6,000 squares of B-deck, painted 22 gauge. A total of 488 tons. By going to a 23 gauge deck, the project experienced an 8% reduction in decking costs and a 2% overall reduction in the joist and deck package. The 23 gauge deck does require weld washers while the 22 gauge doesn’t, but the erector will have fewer required attachments with the 23 gauge deck. So here again, material choice is an important cost consideration. If a lighter gauge of metal can meet the same load requirements as a heavier gauge, a proactive engineering relationship will communicate early in the design phase of a project.

Architects often want to know what’s new in the way of construction materials. Special profile steel joists are always new, from the standpoint of design flexibility.

Special Profile Steel Joists

- Arch (barrel)
- Gable
- Scissor
- Bowstring
- Hybrid



Special profile steel joists consist of four basic profiles. These are barrel, gable, scissor, and bowstring. However, hybrid combinations of these designs can make for almost unlimited architectural possibilities.

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Special Profile Joists

- Endless possibilities for profiles, loadings and applications
- Also used to achieve roof accents and unique architectural elements
- “Deeper is cheaper” often the case
- Increase spacing to reduce piece counts
- Reduce hours of erection labor

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Special profile joists and the design-build approach go well together, because these types of joists must be considered early in the design process. It has been said of special profile joists, that deeper is cheaper. This adage is often true, but not always. As with all types of steel joists, two fundamental ways to conserve costs is to either reduce weight or reduce the number of joists. Deeper can be cheaper, but it also increases the weight of each joist – a cost that can be offset by reducing the number of joists and the number of hours of related erection labor.

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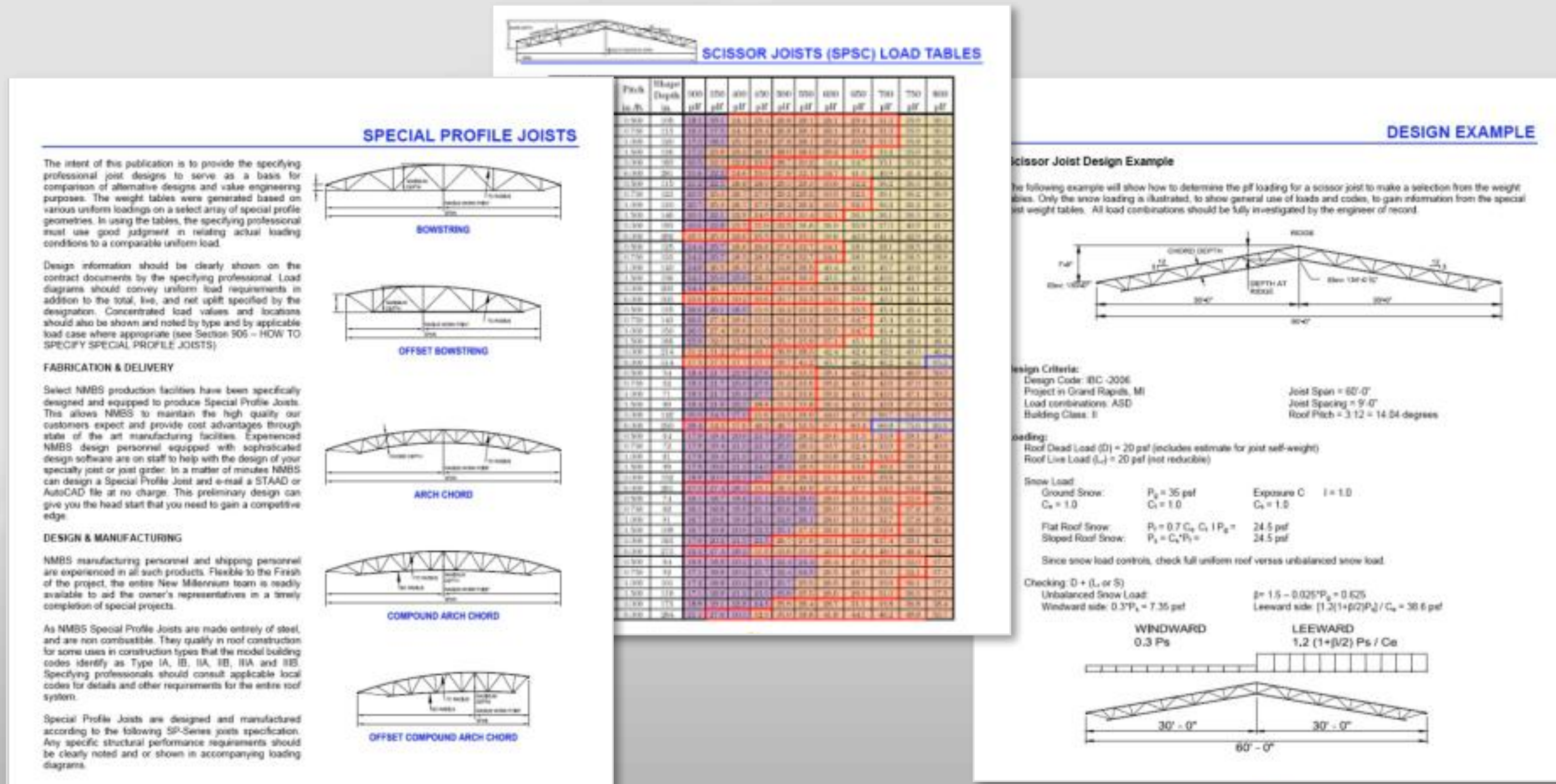
Special Profile Joists

Expanded specification tables



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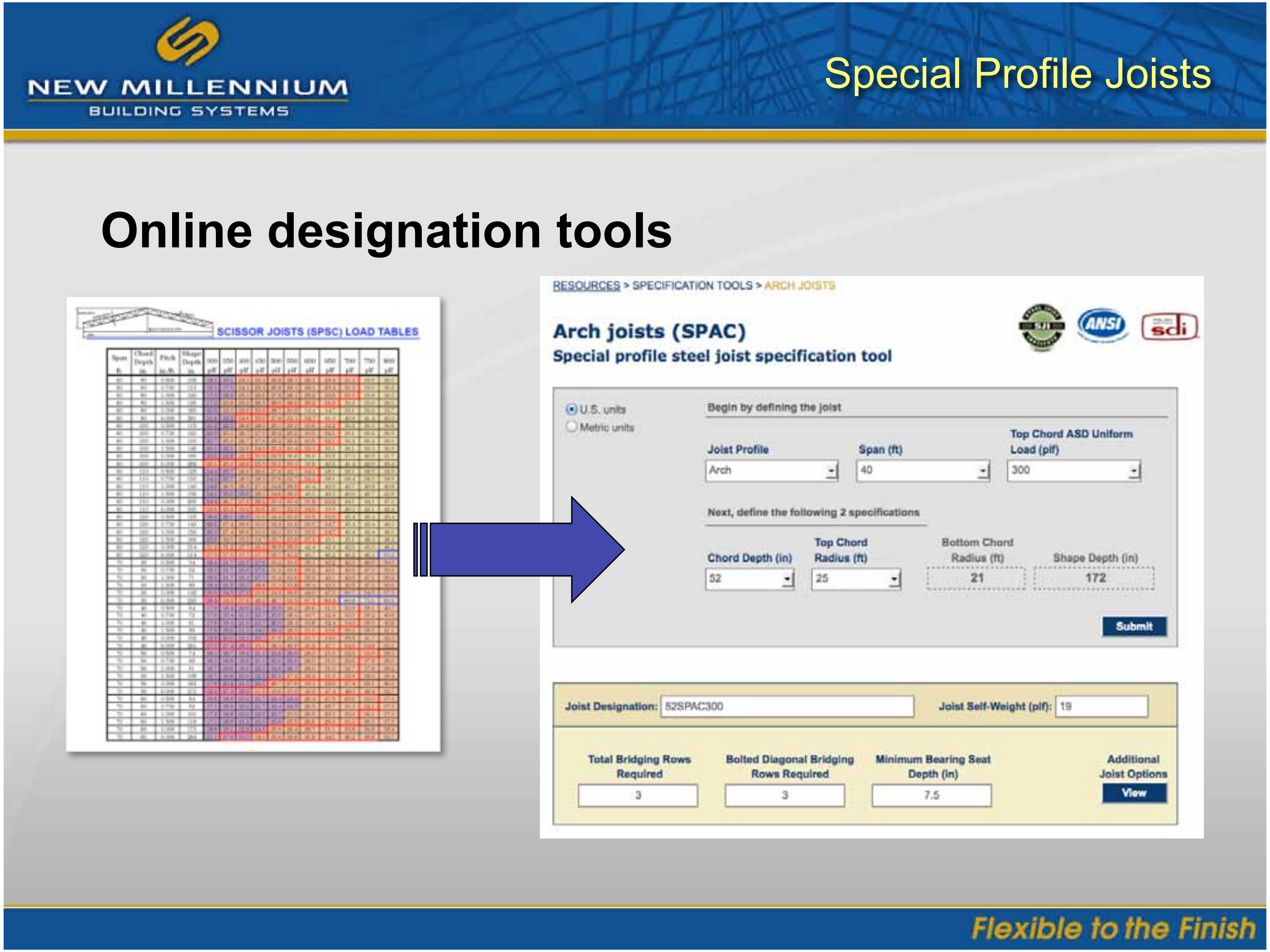
The specifications for these types of joists have been greatly expanded in recent years. Thousands of combinations of design parameters have been factored.



And here again, joist suppliers have developed database-driven specification tools, so it is much easier to cost-compare joist designation based on application.

Special Profile Joists

Evolved joist manufacturing

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At the same time, joist suppliers have invested in more flexible chord rolling and rigging systems. More customized steel joist designs can be produced.

The architectural possibilities of special profile steel joists have yet to be fully explored. Working together at the concept stage, the architect, engineer and joist company can think in new directions.

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Special Profile Joists

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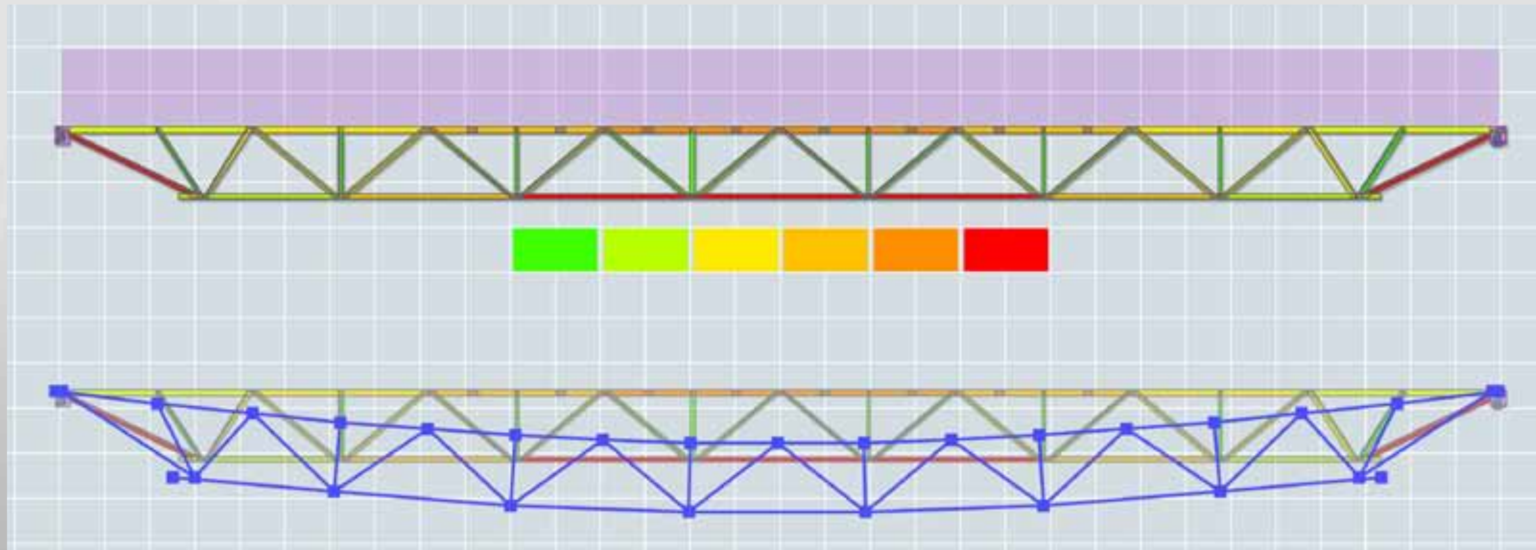
And it will be up to the discipline of engineering to find the most cost effective ways to get there.

Tension-Controlled Steel Joist Design

Tension-controlled open web steel joist design:

An alternative approach to steel joist design, for improved reliability and safety under gravity overload conditions.



Within the last year, an alternative approach to steel joist design has been acknowledged by various construction trade organizations. Ductile tensile yielding is a well established engineering principle. But it has only recently been explored in the context of steel joist design. The approach introduces a "bend before it breaks" joist behavior that is optimal in the event of roof overload conditions.

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Purpose

- Increased strength
- Higher reliability index
- Improved ductility
- Optimal overload sensoring

Tension controlled steel joist design incorporates a limit-states approach to design a tension-controlled joist. It results in a joist that characteristically displays both higher strength levels and large inelastic deformations prior to collapse.

Tension-Controlled Joist Design

- **AISC Engineering Journal**
- **Steel Joist Institute (SJI)**
- **Early branding (Flex-Joist™)**

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The approach was published in the AISC Engineering Journal in the first quarter of 2014. The approach also exceeds the strength requirements of the Steel Joist Institute. And there has been some early branding efforts in regard to the approach.

Tension-Controlled Joist Design

Improved reliability index and probability of more response time

- Reduced variance in strength
- Reserve inelastic capacity
- Load sharing with adjacent joists
- Slower collapse mechanism
- Sensory warning prior to collapse

The main characteristics of the tension-controlled steel joist design approach are improved reliability and safety. Strength is more uniform across the steel joist system. Acting as a system, the joists have greater yielding capacity and a deflecting joist will share its load with adjacent joists. This provides for large roof joist deflection prior to loss of strength.

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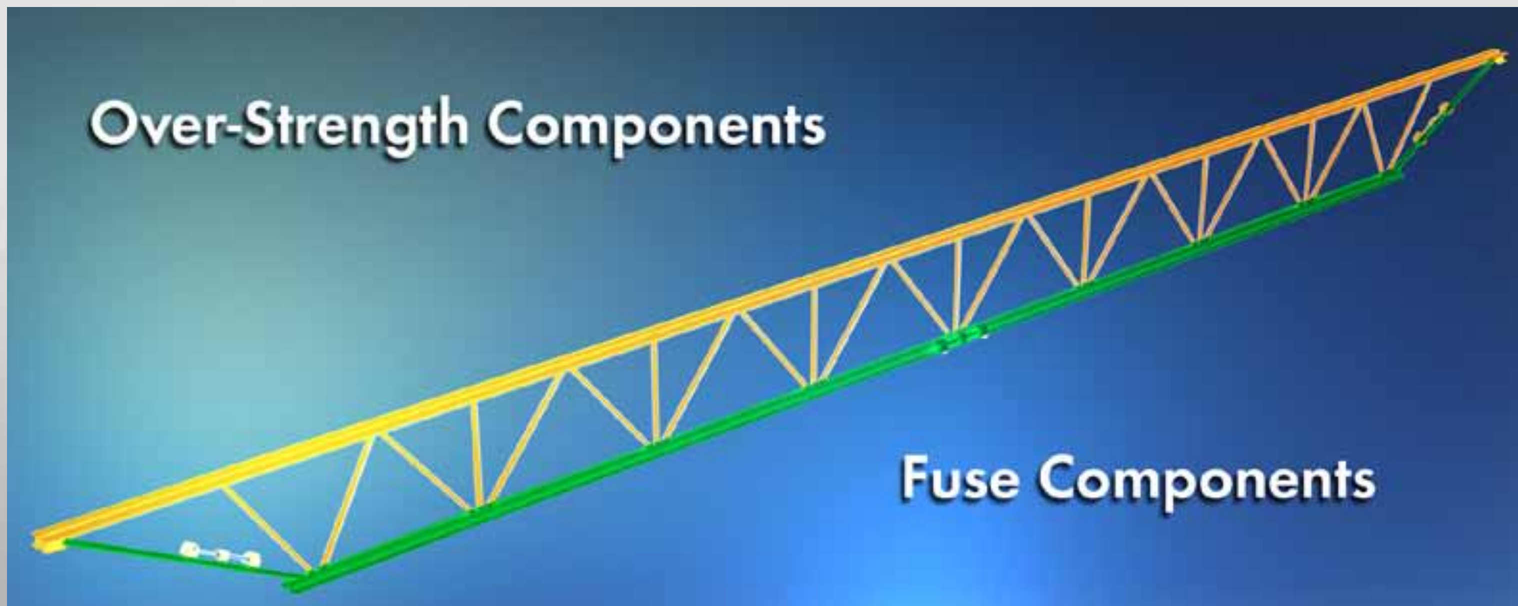
The engineered limit state

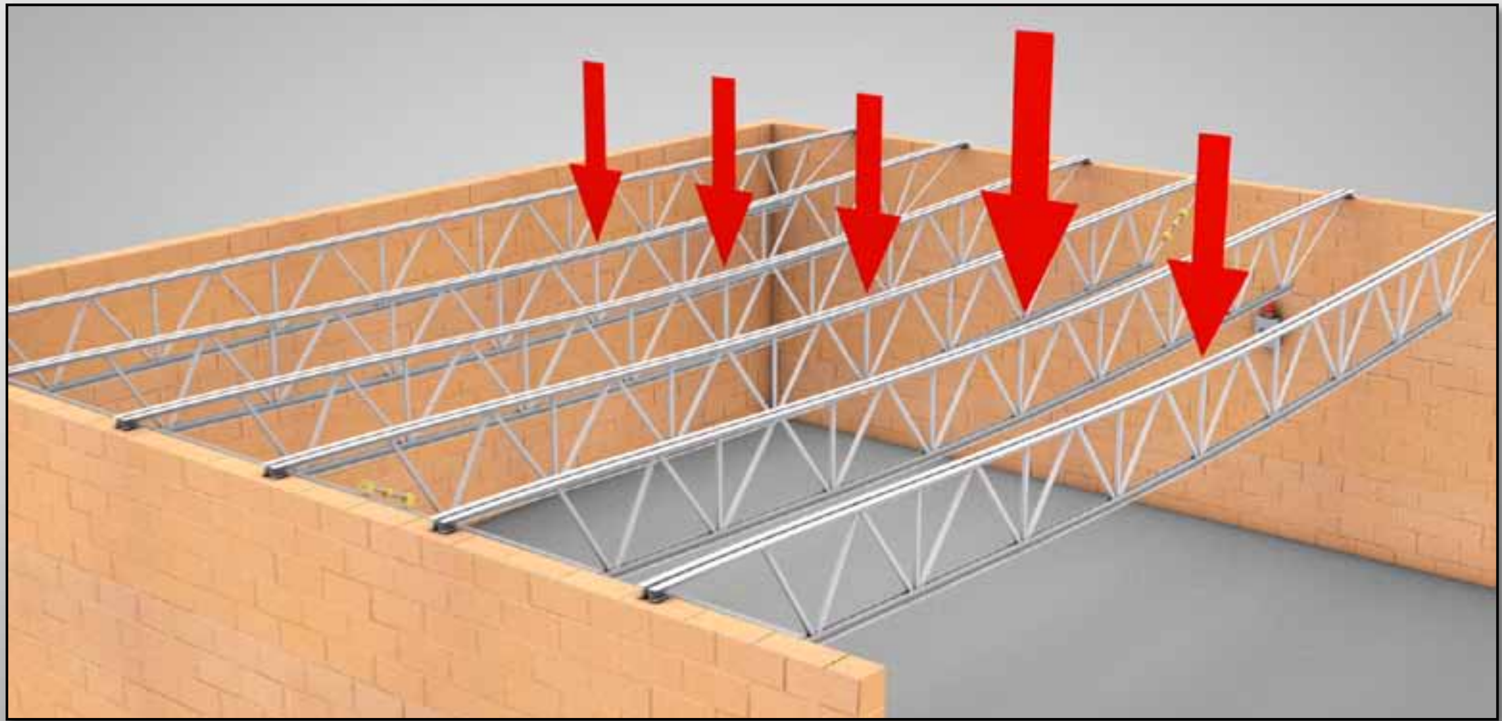
- Intentionally imbalanced member strength ratios
- Selected components serve as "ductile fuses"
- Initial limit state of ductile yielding in primary tension members
- Other limit states inhibited until advanced state of collapse



By establishing a limit states design, the joist uses the primary tension components to serve as a "ductile fuse" under extreme downward-acting loads. The compression members are designed to be over-strength relative to the primary tension members. This resulting ductile tensile yielding limit state is characterized by gradual yielding resulting in extreme deflections prior to collapse.

Design advantages

- Deflection followed by adjacent joist load sharing
- Extends timeframe prior to system collapse



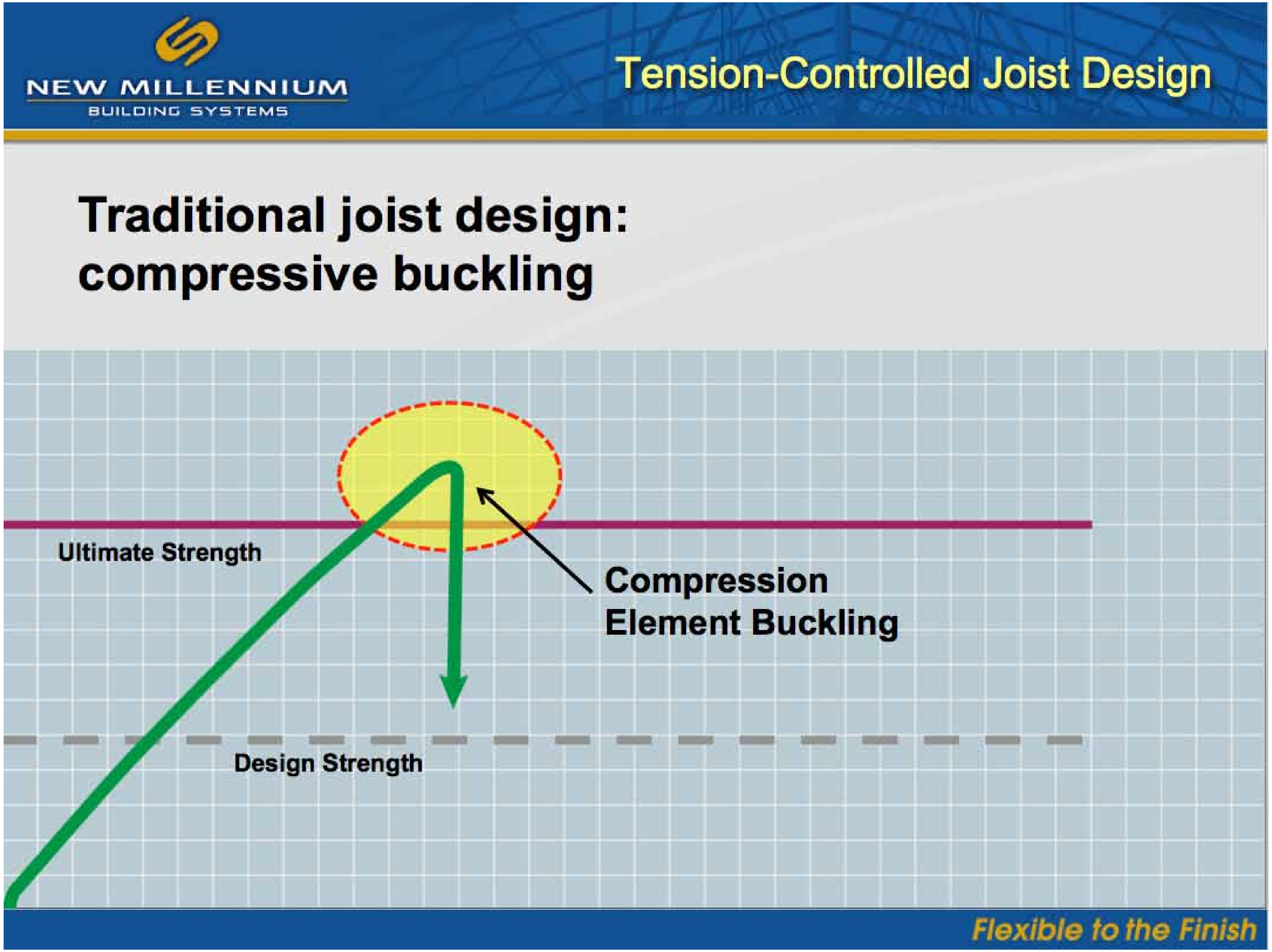
One of the advantages of the approach is that each joist in the system can be designed to share loads and sustain their plastic load capacities while undergoing extreme deformations. The result is load sharing, rather than load dumping, which occurs with standard joists.

Electronic Monitoring Options

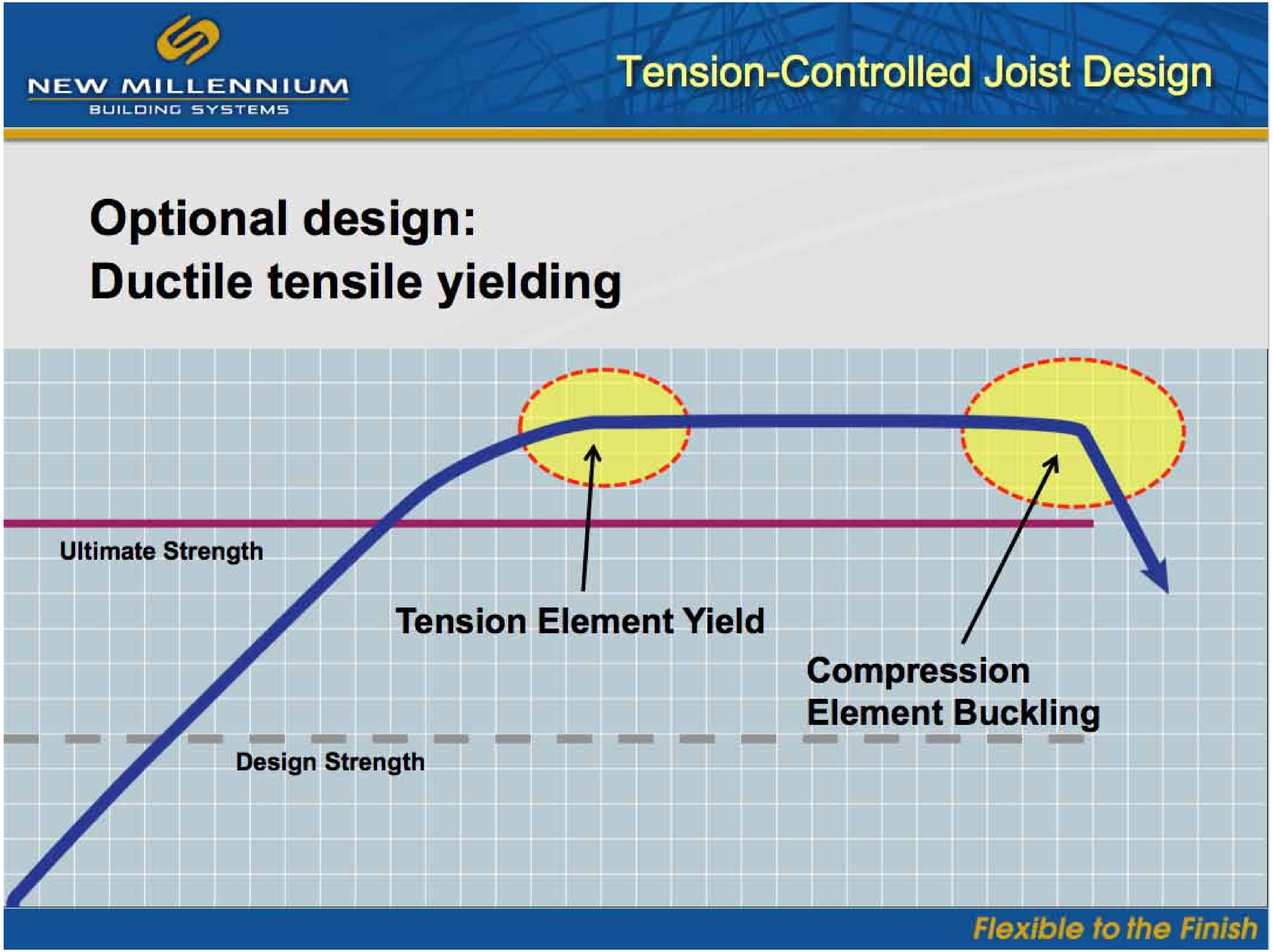
(by third party provider)

- Early warning alarm system
- Strain and/or deflection monitoring
- On-site and/or remote monitoring

For the ultimate in safety management, a tension controlled joist installation can be affixed with electronic sensors and alarms post-erection by a third party provider to provide an optionally integrated overload warning system.



Traditional joist design is based on controlled compression buckling. The joist will withstand a downward force until it exceeds the joist load bearing capacity. When the compression load bearing capacity is exceeded, the slender compression elements will buckle precipitously and the joist will collapse with very little advance warning. The traditional joist safely supports the anticipated loads with a good margin of safety. However, in the event that the joist is ever subjected to extreme loading in excess of the design safety factor, when the joist finally collapses, the collapse is usually quite sudden with little warning.



In contrast, with the Flex-Joist design, in the event of overload, the tension elements yield so as to provide a significantly longer delay. This delay is characterized by extreme deflections prior to compression element buckling and the collapse of the joist. This provides time to warn of the possible impending collapse.

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Tension-Controlled Joist Design

Joist Performance Comparison			
Criteria	**Std Joist**	**Flex-Joist**	**% Diff**
Joist Strength Reliability β	2.6	3.2	22%

System β based on N = 4 statistically unlinked joists working in parallel

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This table compares the performance of the standard SJI joist engineering approach to the performance of the ductile tensile yielding engineering approach.

The AISC specification, on which the SJI specification is based, reports an approximate relative reliability index of 2.6. The ductile tensile yielding approach has a calculated reliability index of 3.2 based on statistical analysis of joist test results and mill test data on our primary tension members. This is a 22% improvement in reliability index, which translates directly to reduced probability of collapse.

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Tension-Controlled Joist Design

Joist Performance Comparison			
Criteria	**Std Joist**	**Flex-Joist**	**% Diff**
Joist Strength Reliability β	2.6	3.2	22%
System Strength Reliability β	2.6	3.4	31%

System β based on N = 4 statistically unlinked joists working in parallel

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The ductile limit state promotes load sharing between adjacent joists in the inelastic range. This load sharing further reduces the strength variance. Rather than system strength being limited by the weakest (or most heavily loaded) joist, it becomes a function of the average strength (or average loading) of all the load sharing joists. For a system of four joists working in parallel, the system reliability index may be shown to be β = 3.4, or 31% higher than the industry standard. That increased reliability computes directly into a reduced risk of failure. It improves the probability that the joist roof or floor system will survive an extreme loading event in excess of design loads.

Tension-Controlled Joist Design

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Joist Performance Comparison			
Criteria	**Std Joist**	**Flex-Joist**	**% Diff**
Joist Strength Reliability β	2.6	3.2	22%
System Strength Reliability β	2.6	3.4	31%
Average Test Strength Ratio	1.8	2.3	29%

System β based on N = 4 statistically unlinked joists working in parallel

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Laboratory testing has demonstrated the approach to be almost 30% stronger, on average, than a traditional SJI joist. The traditional SJI joist has an average strength ratio of 1.8. which compares well against the ASD design safety factor of 1.67. However, the new approach demonstrates a substantially improved average strength ratio in excess of 2 times the service loads. This is done simply by increasing the strength of the compression members, which commonly control the test strength of traditional SJI joists.

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Tension-Controlled Joist Design

Joist Performance Comparison			
Criteria	**Std Joist**	**Flex-Joist**	**% Diff**
Joist Strength Reliability β	2.6	3.2	22%
System Strength Reliability β	2.6	3.4	31%
Average Test Strength Ratio	1.8	2.3	29%
Average Test Ductility Ratio	1.4	3.2	129%

System β based on N = 4 statistically unlinked joists working in parallel

Flexible to the Finish

The ductility ratio is the deflection at maximum test load divided by deflection at elastic limit. As you can see, the new approach demonstrates substantial ductility range, whereas traditional joists demonstrate much less ductility. That ductility translates directly into more time for evacuation with more sensory warning of collapse.

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Tension-Controlled Joist Design

Joist Performance Comparison			
Criteria	**Std Joist**	**Flex-Joist**	**% Diff**
Joist Strength Reliability β	2.6	3.2	22%
System Strength Reliability β	2.6	3.4	31%
Average Test Strength Ratio	1.8	2.3	29%
Average Test Ductility Ratio	1.4	3.2	129%
Tension Limit State Probability	Low	High	
Electronic Monitoring Suitable	Okay	Excellent	

System β based on N = 4 statistically unlinked joists working in parallel

Flexible to the Finish

Engineering for ductile tensile yielding is ideally suited to electronic monitoring of deflection and/or strain for early warning of high loads. This allows time for building evacuation, load removal, and/or shoring to prevent collapse.

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Tension-Controlled Joist Design

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Average Test Ductility Ratio	1.4	3.2	129%
Tension Limit State Probability	Low	High	
Electronic Monitoring Suitable	Okay	Excellent	
Average Relative Weight	100%	107%	

System β based on N = 4 statistically unlinked joists working in parallel

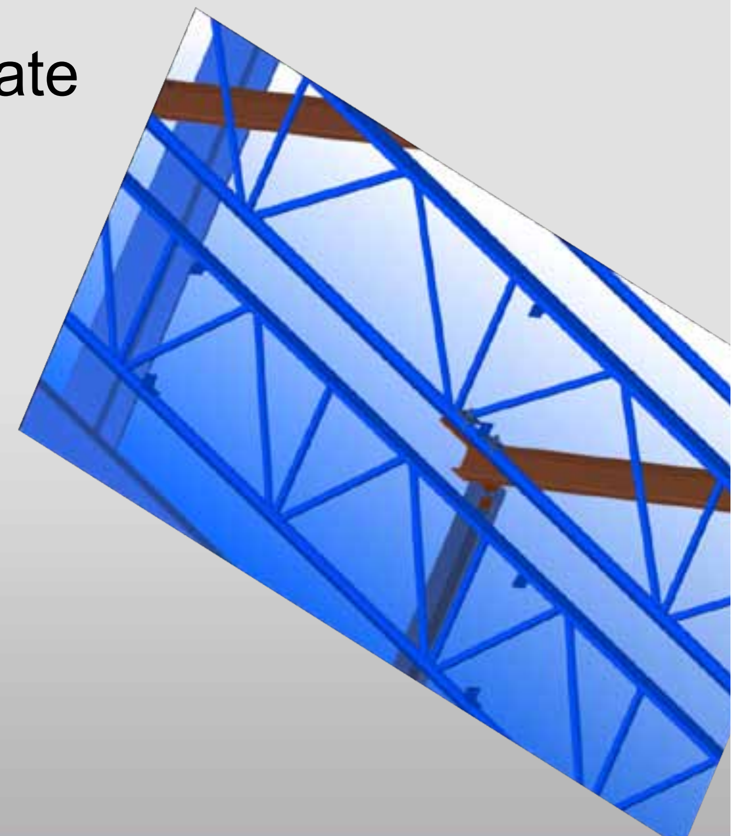
Flexible to the Finish

By selectively increasing the size of only specific components, the ductile joist design provides substantially improved reliability and ductility at minimal additional cost. On average, the tension-controlled joist weighs only 7% more than industry standard joists. That's an average 20% increase in strength/weight ratio using a tension-controlled joist.

Building Information Modeling is no longer a trendy concept. Many design-build firms are now involved in BIM projects.

Status of BIM Adoption

- 74% of contractors in N.A. using BIM
- 28% to 71% increased adoption rate for BIM and BIM related tools
- 74% of contractors see positive ROI
- Higher ROI based on earlier BIM engagement



Source: McGraw Hill Construction
The Business Value of BIM in North America

74 percent of contractors in North America now use BIM. According to research by McGraw Hill, the adoption of BIM and BIM related tools in the North American construction industry increased from 28 percent in 2007 to 71 percent in 2012.

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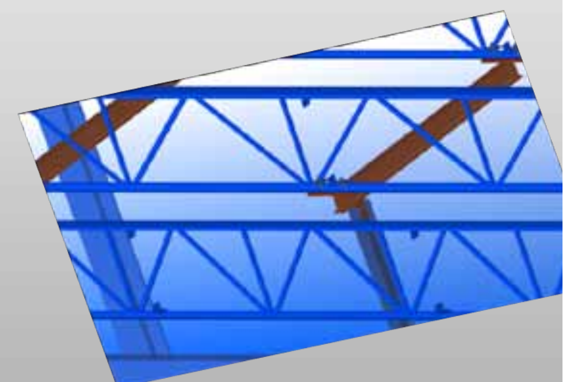
BUILDING SYSTEMS

BIM

Key Finding:

BIM would be the most valuable in support of early collaboration at the trade level, including steel joist, deck and beam design.

Source: McGraw Hill Construction
The Business Value of BIM in North America



Flexible to the Finish

A key finding of the study was that BIM users and non-users all agreed that the best use of BIM would be to foster early design collaboration at the trade level.

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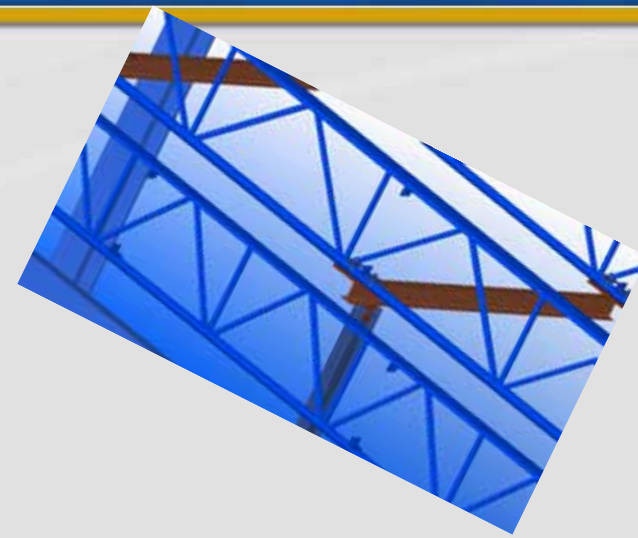
BIM

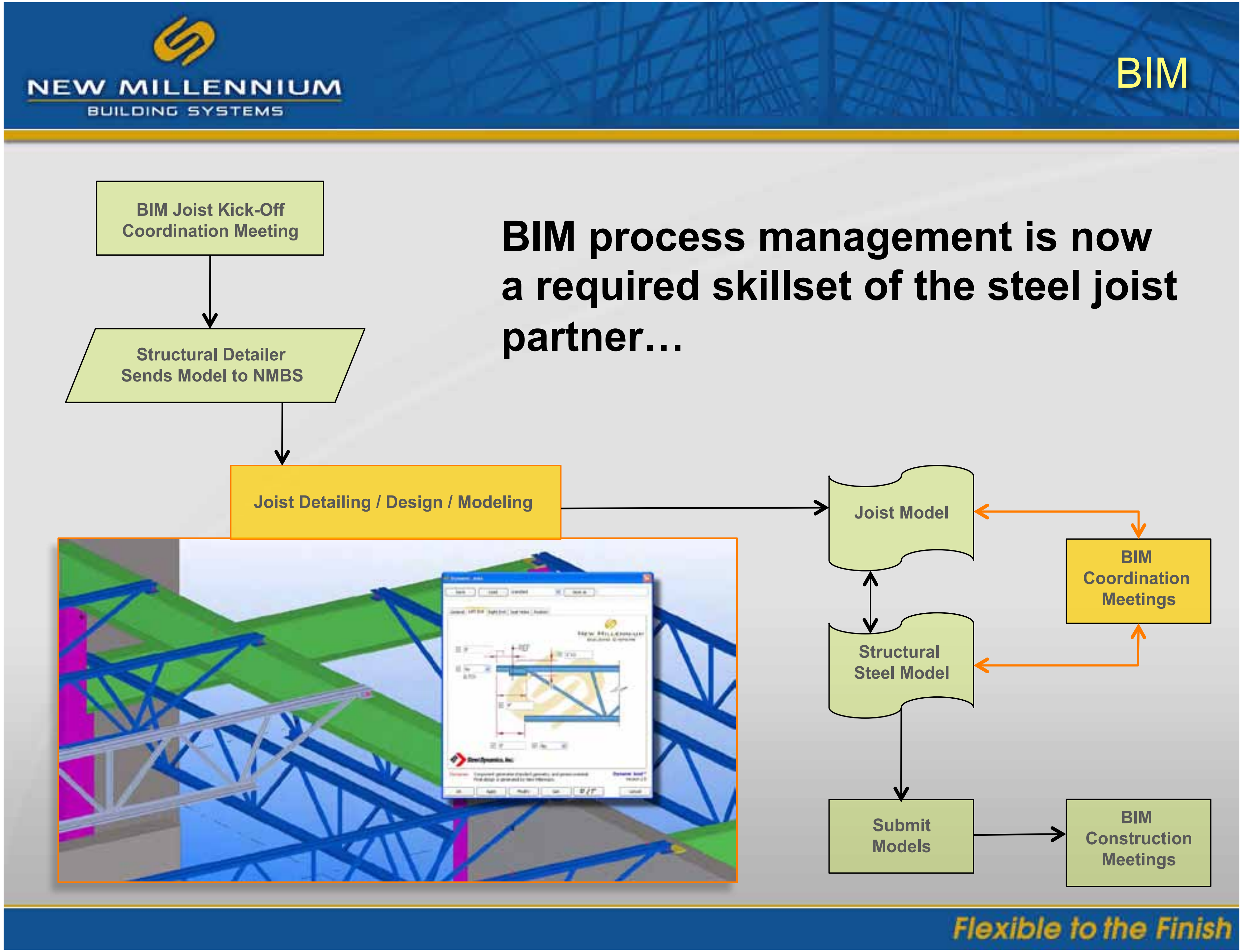


Proven BIM Advantages

- Reduce information requests
- Improve accuracy of construction documents
- Reduce field coordination problems
- Less time drafting and more time designing
- Reduce construction costs

Flexible to the Finish

The research cited several reasons why BIM would be especially beneficial at the trade level. Including improved communications, earlier and better designs, and reduced total project costs. Having an accurate visual model for reference has made an enormous difference regarding steel joist and metal deck engineering decisions. Having a model removes a lot of the guesswork and leads to reduced costs. It gives experienced joist, deck and beam engineers another tool to pursue value-engineering.



BIM has become highly process managed. Proactive joist and deck companies can offer a process for managing the development and integration of their BIM models. They know how to coordinate with the structural steel BIM model, as well as all other BIM models on a project. But as the research has shown, BIM is under-utilized at this level. The increased use of BIM during the steel joist and deck design phase can contribute vitally to total project cost and performance.

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BIM

Digital steel joist design component

Supports the three stages of steel joist design:

1. **Generic joist object for preliminary design**
2. **Use of generic info for detailing-design process**
3. **As-built joist BIM object with end conditions, member sizes**

Joist object is imported into the model…

Flexible to the Finish

The steel joist supplier supports BIM by offering a digital design component. The component enables BIM-based collaboration at every phase -- starting with initial generic joist placement by the detailer; then sharing initial generic joist detailing information, and then the creation of the final 3-D model for discussion and refinement of the plan.

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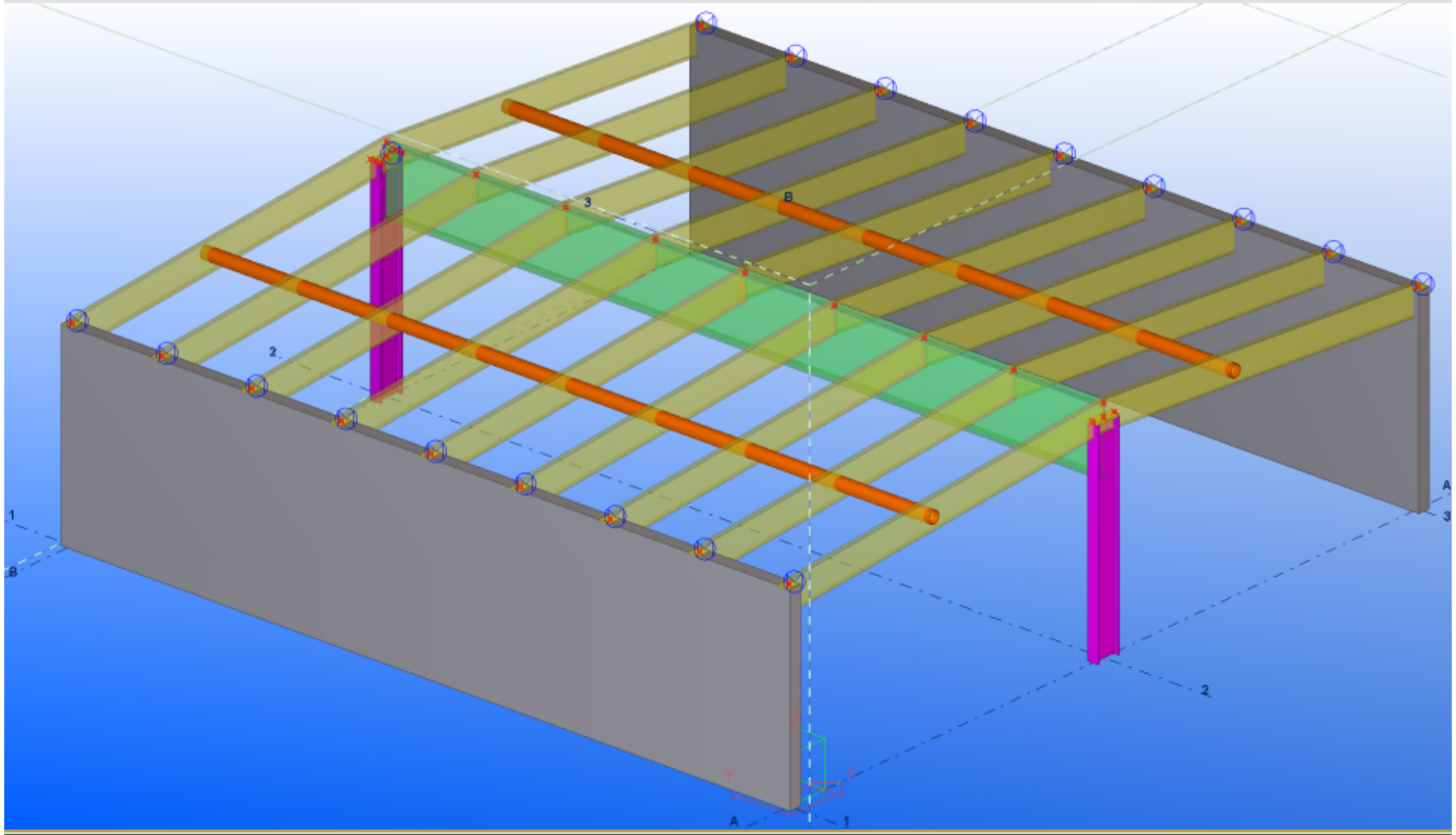
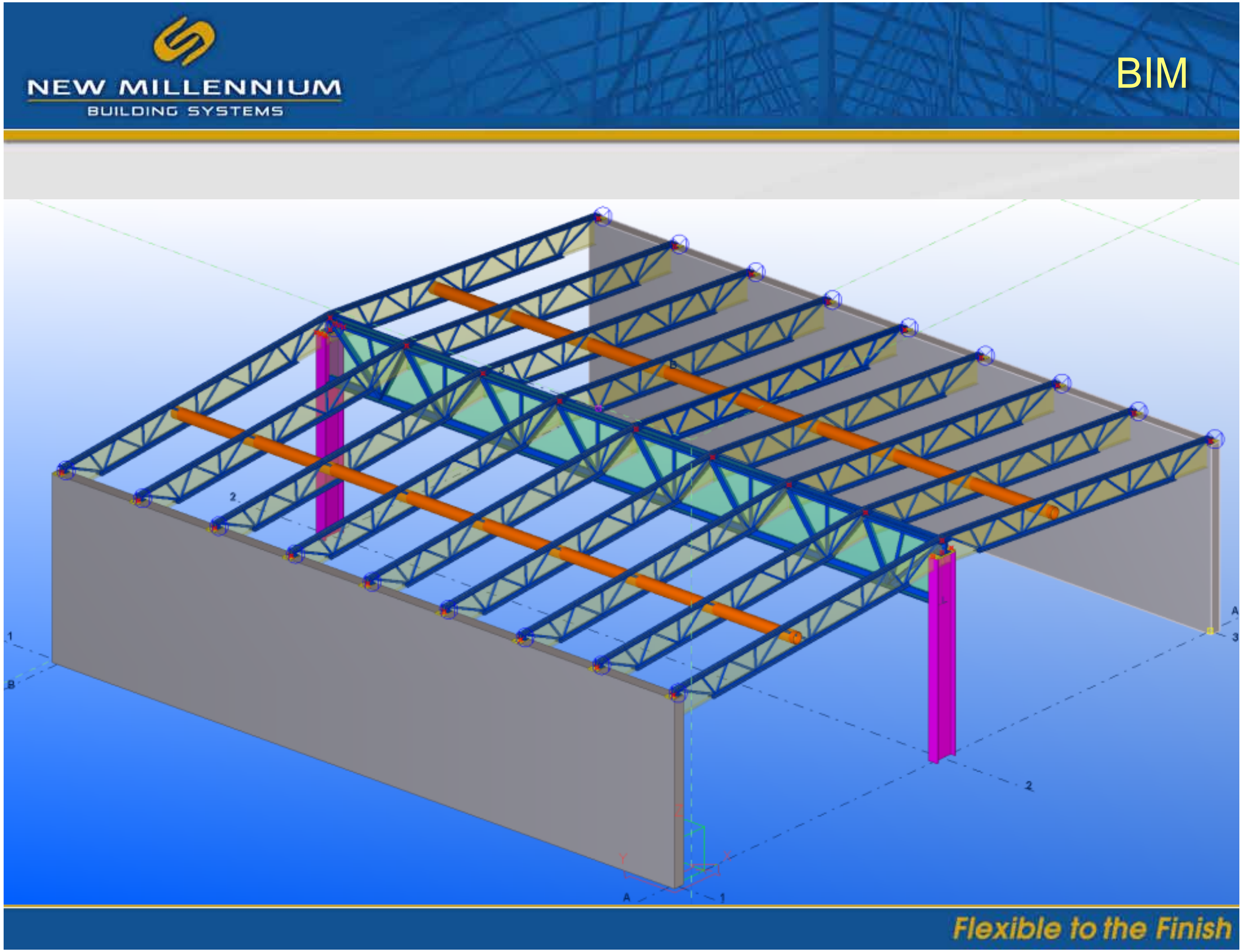
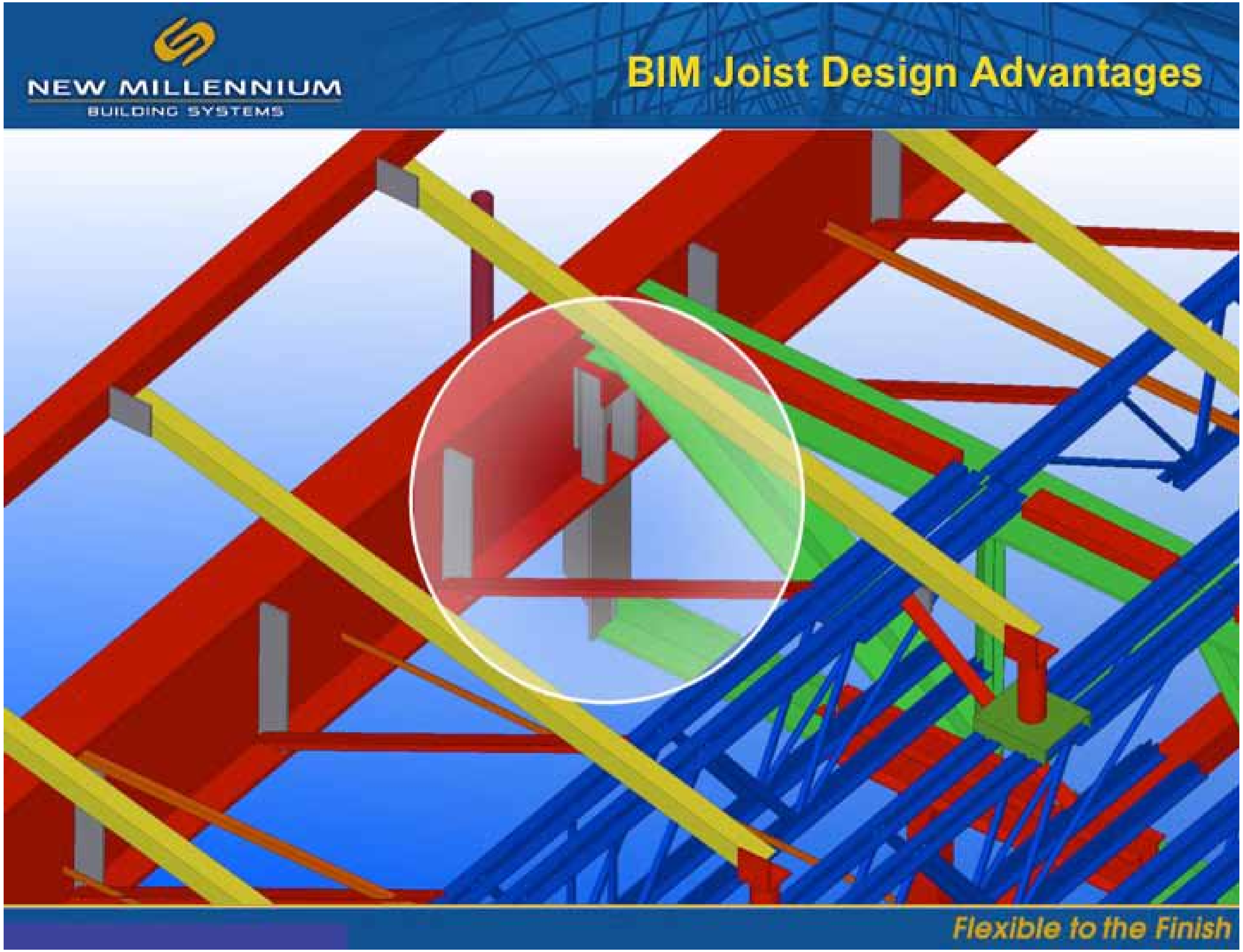


Flexible to the Finish

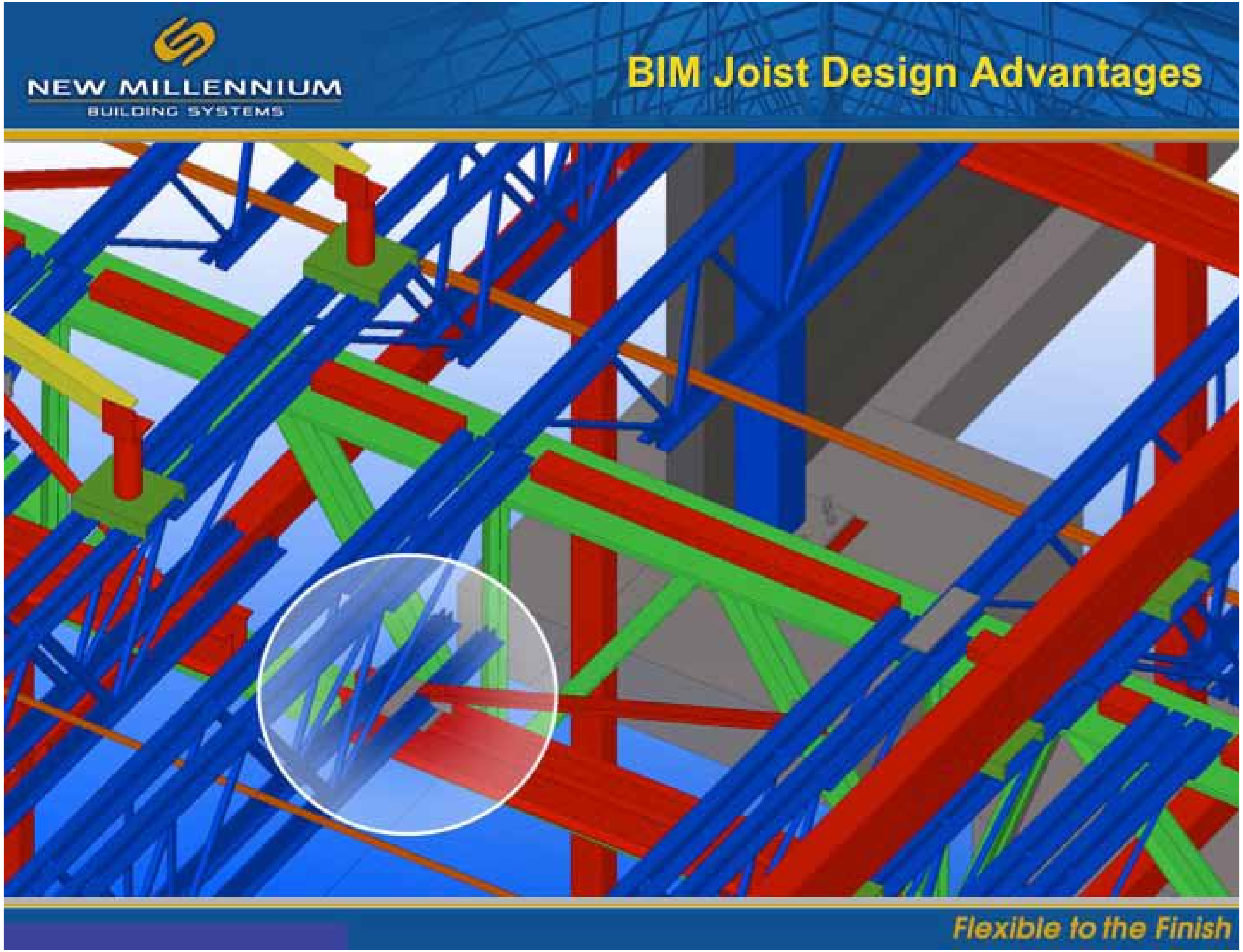
Here is how 3-D digital design works in the steel joist environment. Conventional 2-D design packages will generically represent joists in a drawing.



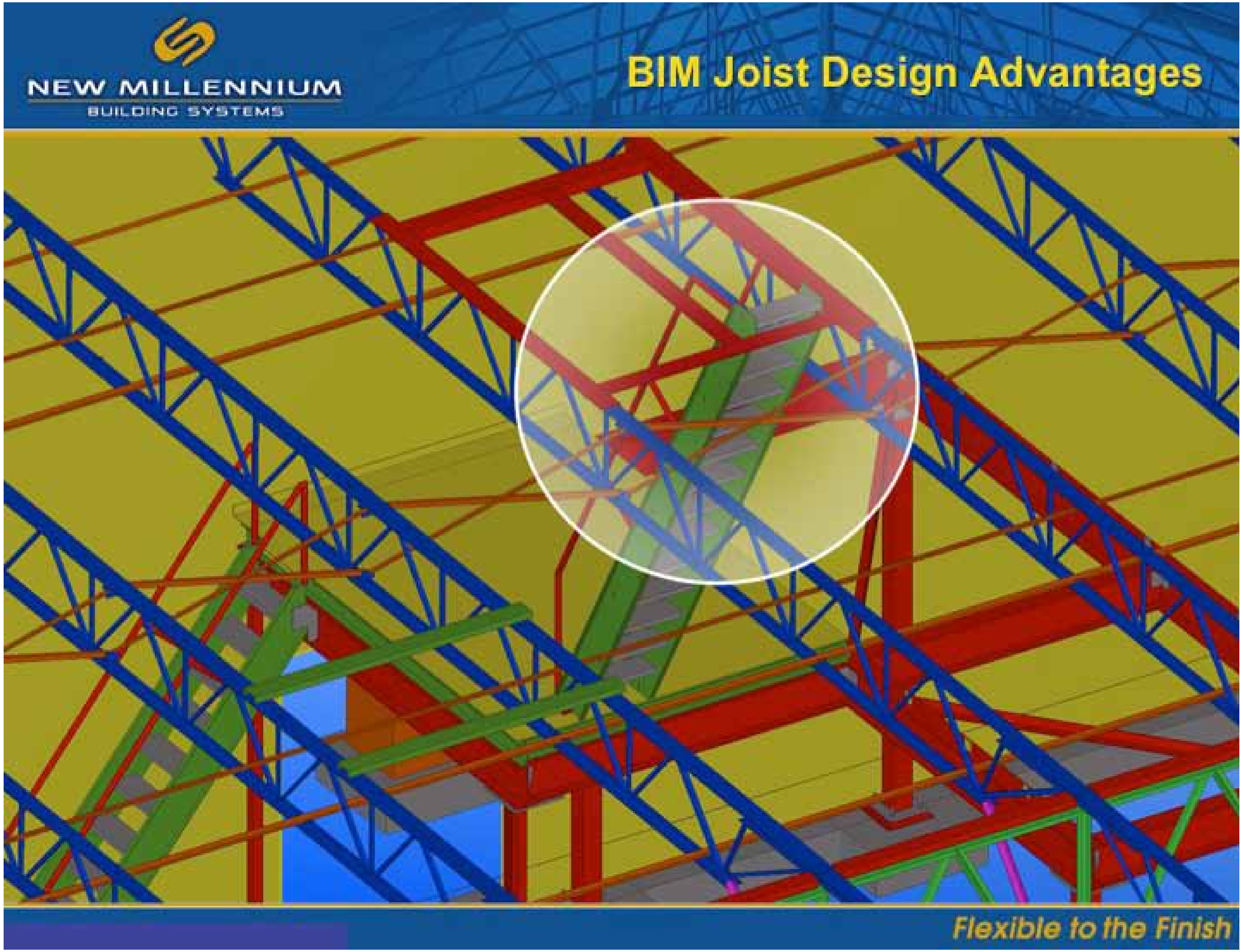
To give these generic shapes actual dimensions, the joist supplier uses a design software component or ”plug-in” compatible with the 3-D structural engineering software.



Let's take a closer look at some of the advantages of BIM joist design. In this actual example, the detailer noticed that he had not provided a stabilizer plate for the bottom chord extension. So he designed a special stabilizer to catch the girder extension, and the joist company fabricated the extension. This was all done before erection, preventing significant on-site correction costs and delays.

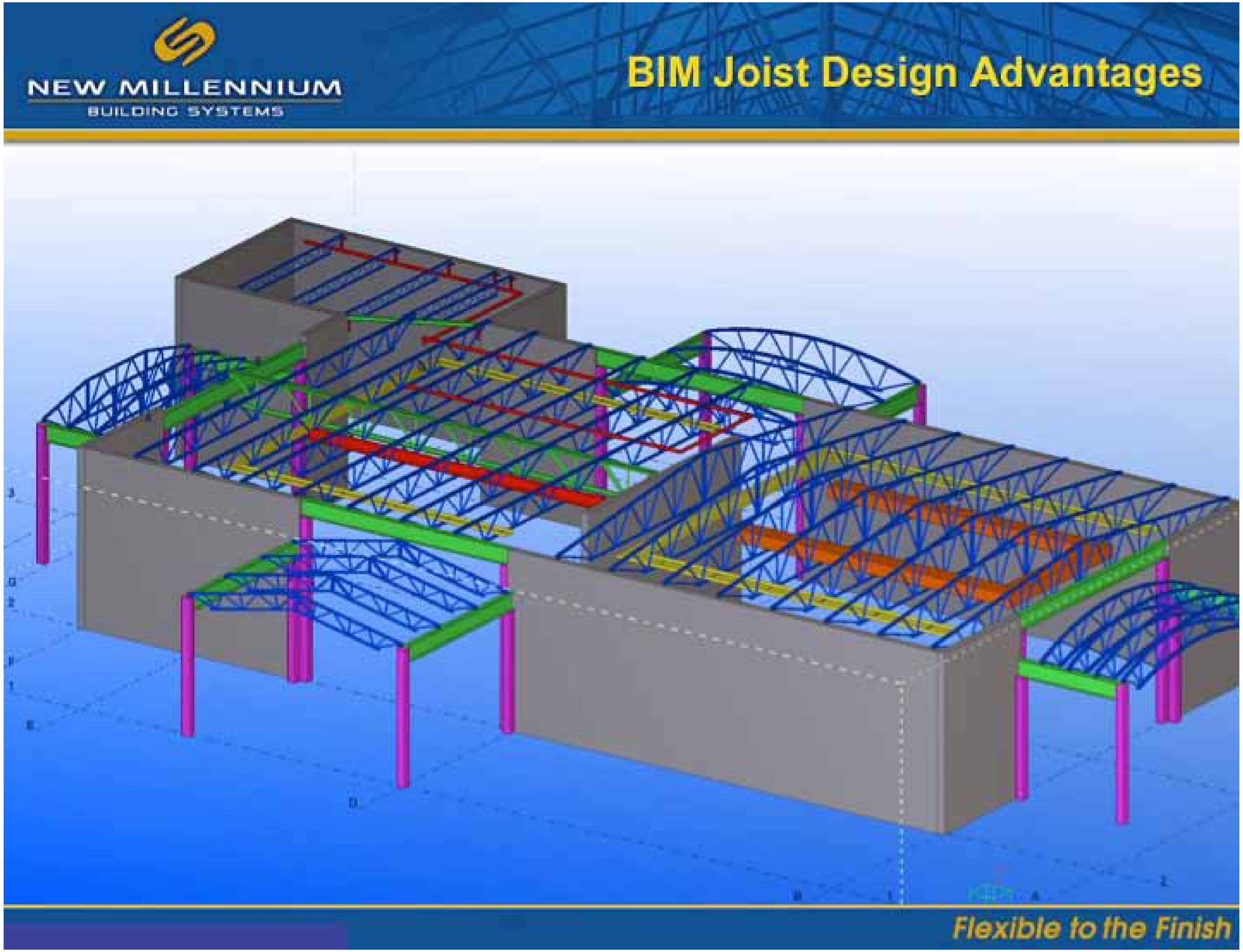


This job originally called for single joists, not the double joists you can see here. The original design did not account for the special loading on the joists that would be caused by special mechanical units positioned overhead. In the BIM model the absence of the double joists flagged a serious problem, which was corrected by using the double joists. You can see here that the steel detailer also included channel support under the double joists to further address the mechanical load requirement.

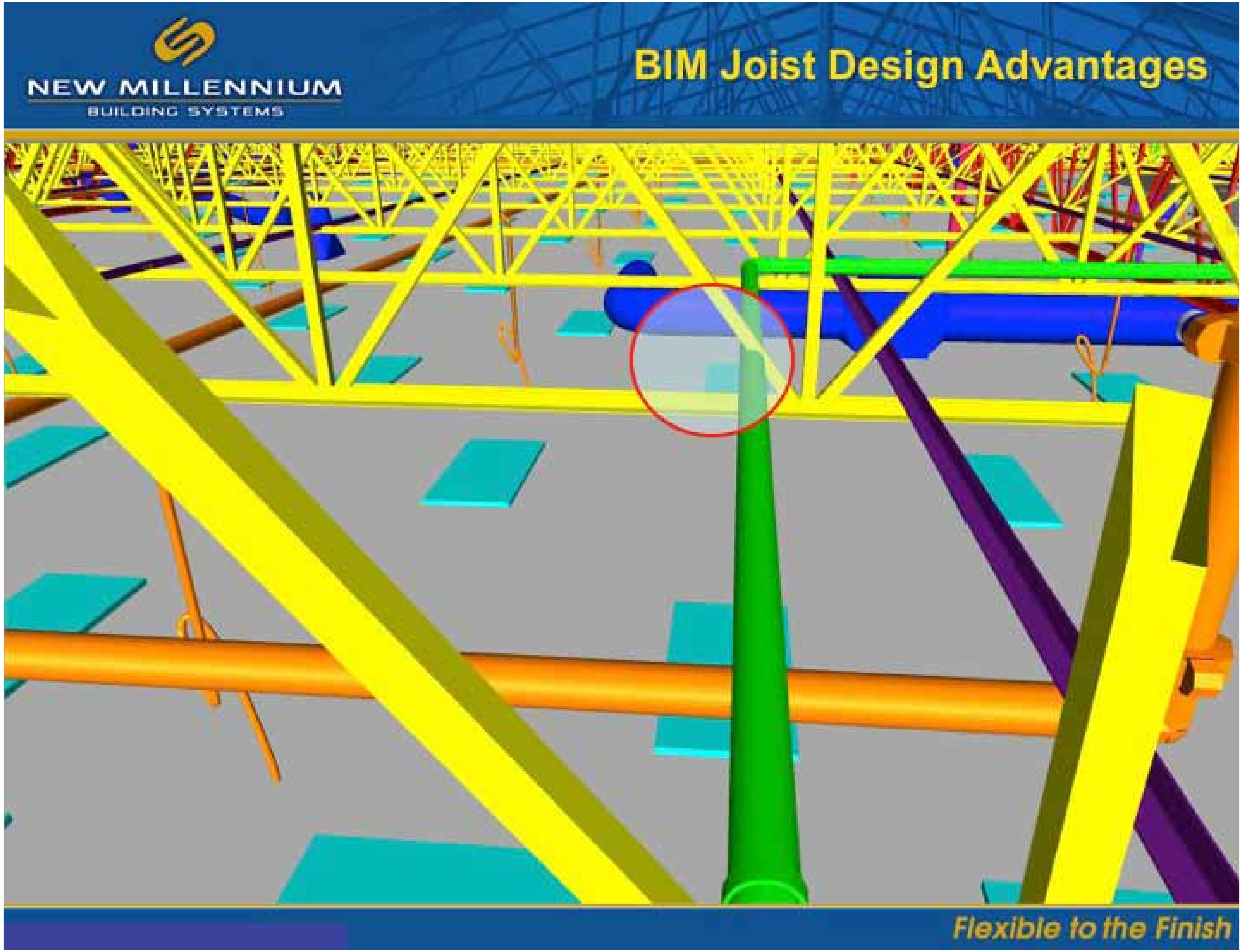


In this example, the BIM joist model assisted other building design efforts such as the location of roof drain supports. The detailer even used the model to integrate a ladder into the design for access to the roof drains.

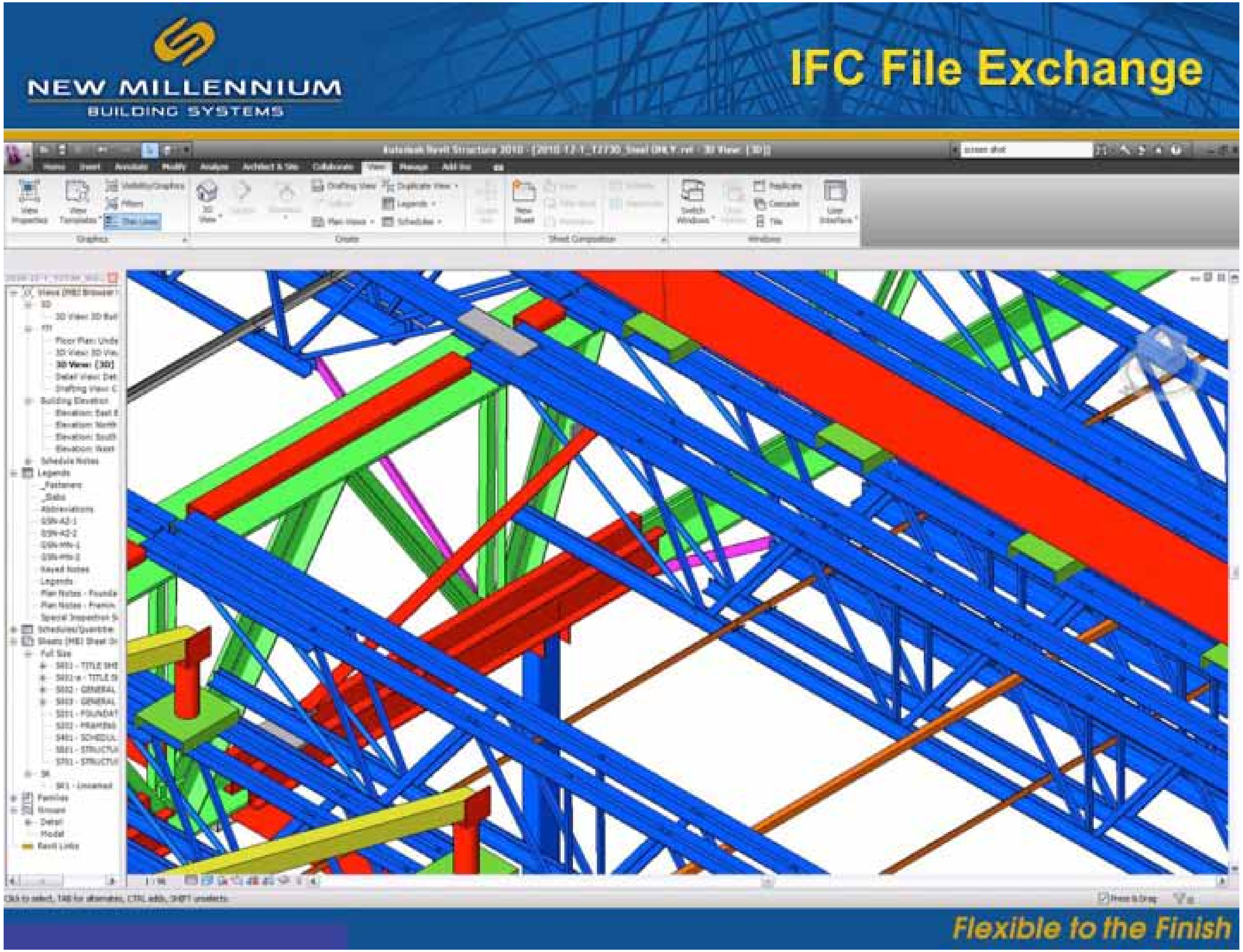
Back charges are common, when early design collaboration is missing. In this example, the BIM model clearly revealed that one of the joists was lacking a bottom chord extension and the bearing angle was wrong. The problem was quickly corrected and the joist model back was sent back to the detailer. This problem would not have been caught in the traditional 2D approach.



The BIM process moves the design from joist detailing to actual dimensional joists. As the joists are designed, the model is updated and you can now see the fabricated joists. At this stage, all the participating trades can benefit from the joist model. You can see how components such as ductwork and piping can be coordinated through the web system of the joists. Notice the cable trays running through the webs. Having the fabricated joists in the model enables the design of cable trays within the web system. This could lead to raising the ceiling of a room, which is a cost savings in material.



A key step in the steel joist BIM process is the holding of pre-construction meetings. These meetings enable all participants in the project to discuss joist related potential problems – before erection. The model also allows the participants to suggest improvements or alternatives that may not have been realized earlier in the project. Team members from the various trades participate in an "in-model" review of the project. This virtual tour is usually accomplished through a web conference.



An early impediment to the adoption of BIM was the exchanging of files. The IFC model format is now a common deliverable on BIM projects. The IFC file format is widely supported and is fostering the goal of interoperability with other trades. The steel industry is now working with organizations like the AISC and the AISI to refine the steel standards for the IFC file exchange format. So no matter which brand of structural design software is used, the resulting file can be exchanged with other project design participants using the IFC file exchange method.

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BIM

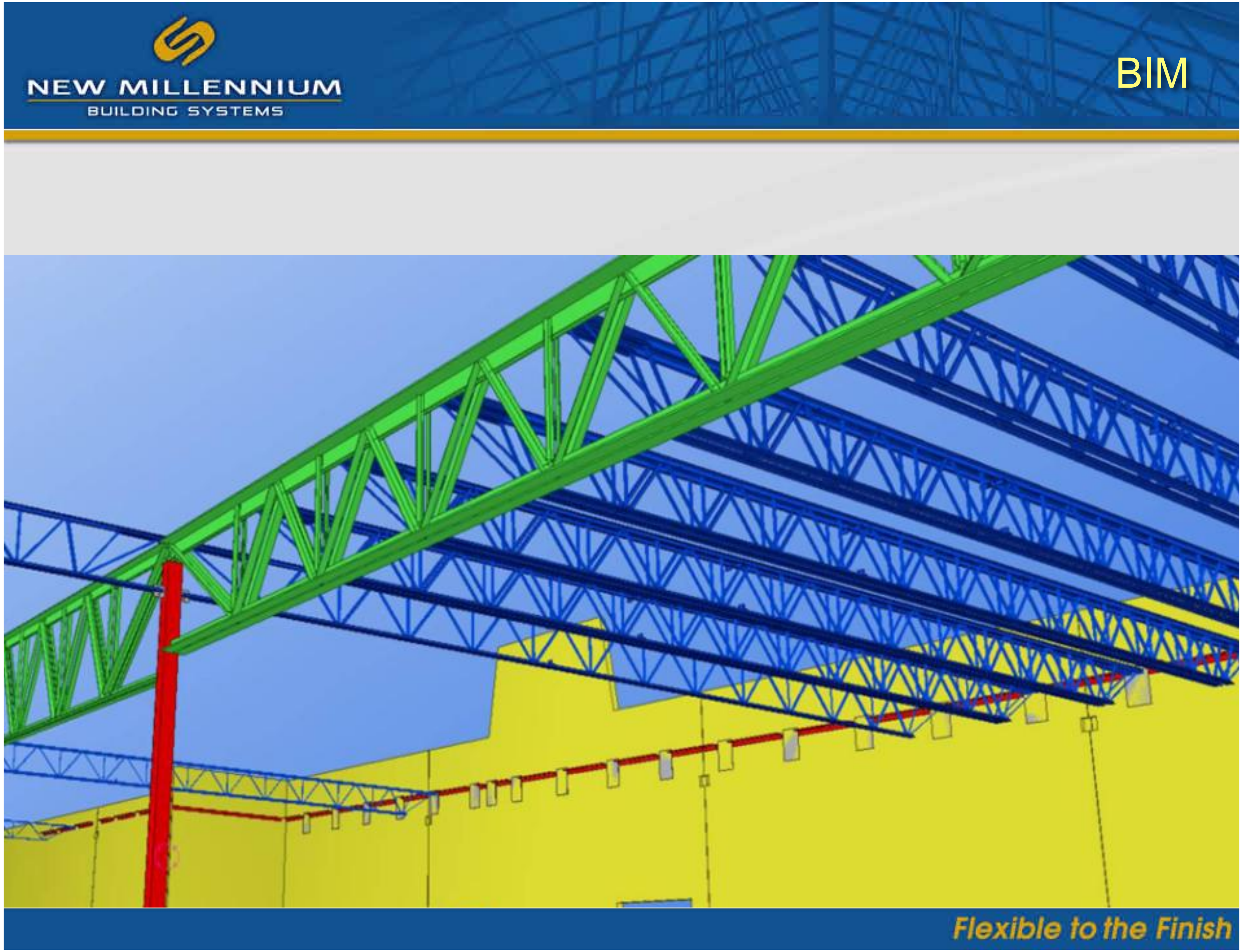
Major Retailer

- First-ever total BIM approach for the retailer
- Structural package, joists, modeled in 3-D BIM
- Timeline for shop drawings:

  Originally 10 weeks… to 3.5 weeks
- Minimized and integrated HVAC / electrical space

Flexible to the Finish

BIM-based design projects are especially effective from the owner's point of view. During the digital design phase of the joists on this BIM project, many cost saving opportunities are presented. For this project, the entire structural package, including joists, were modeled in 3D BIM, using the Autodesk Revit platform. The timeline for shop drawings moved from 10 weeks to three-and-a-half weeks. This was about a 50% reduction in the timeline. Another goal of the BIM project was to better utilize the MEP space around the steel joists in the stores.



With the use of BIM, a project can move from concept to reality much more efficiently and cost effectively.

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BIM

Flexible to the Finish

Conclusion

This concludes this course for

1.0 PDH credit or

American Institute of Architects
Continuing Education Systems Program
AIA 1.0 LU credit.