Introduction

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{Structural Option}

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Building Statistics

Project Overview

- Proposal
- Gravity System
  - Redesign
  - Vibration Control
- Lateral System
  - Moment Frame Layout
  - RAM Model
- Cost & Schedule Analysis
- Architectural Impacts
- Conclusions

220, 000 GSF

13 stories above ground

Multipurpose (Admin, Classrooms, Labs)

$159 million

October 2009 to March 2013

Designed for LEED Silver Certification

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Primary Project Team

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Virginia Commonwealth University — MCV — RPI — 1838

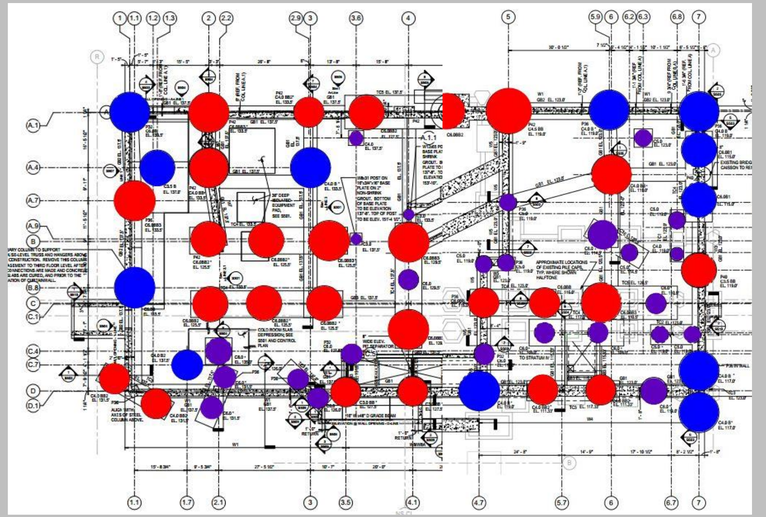
Gilbane

BALLINGER

PEI COBB FREED & PARTNERS *Architects LLP*

Existing Gravity System

Drilled piers + caisson-grade beam system



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Existing Gravity System

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Drilled piers + caisson-grade beam system

Composite Steel Flooring

3” 20 gauge decking

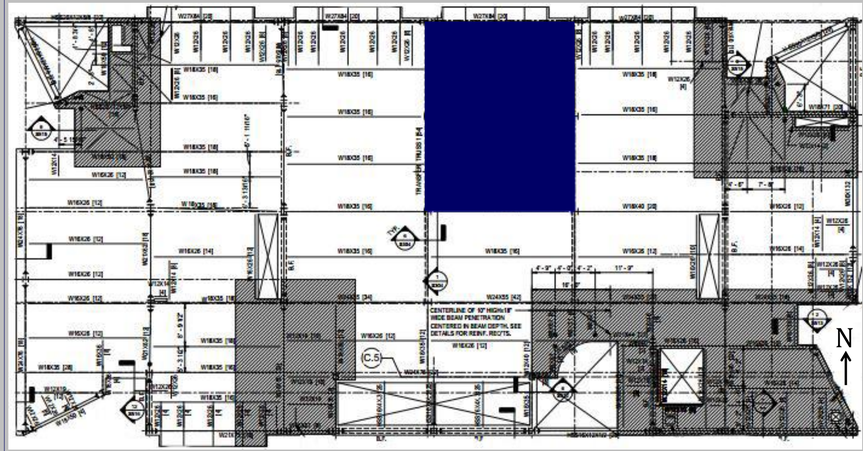
3 ½” LW concrete topping

Wide Flange Steel Beams + Girders

Typical Bay Sizes

30’ x 20’

30’ x 40’



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Existing Lateral System

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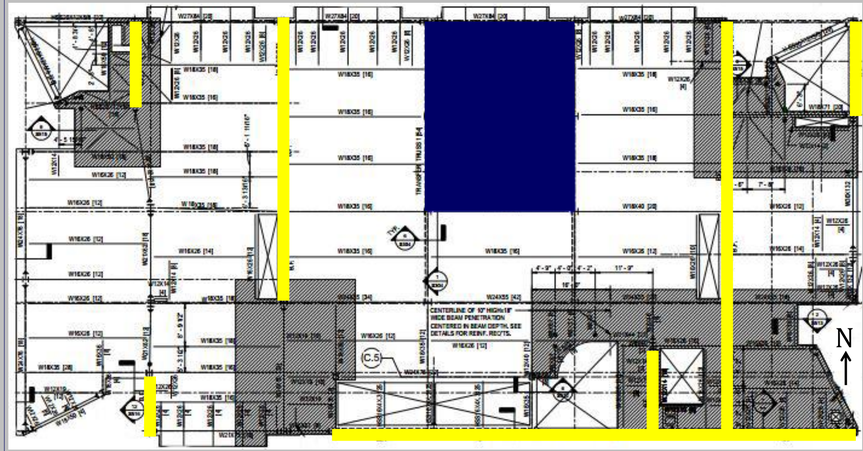
Concentrically braced frames + moment connections

7 total, majority in one direction

Both wide flange + HSS



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Opportunities

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Increase efficiency of structural system

Save both time + money

In line with VCU SOM reinvented curriculum, create open environments

VCU SOM

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Opportunities

Increase efficiency of structural system →

Save both time + money →

In line with VCU SOM reinvented curriculum, create open environments →

Proposal

Design alternate structural system

Non-composite deck + K-series joists + girders

Heavier emphasis on use of moment frames

Evaluate cost + schedule of redesign

Structural Costs vs. Total Project Costs

Investigate impacts on Architecture

Can a more open concept be achieved?

Can improvements be made?

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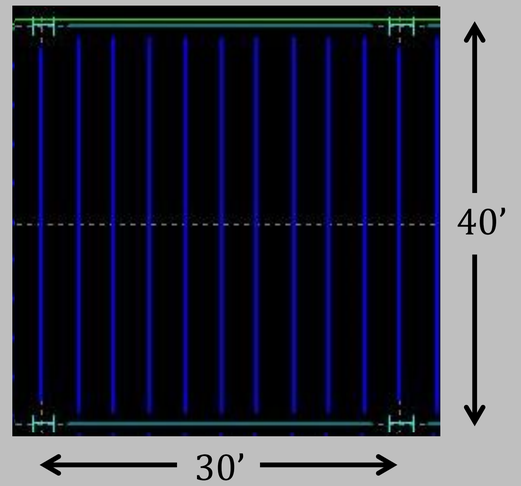
Gravity System

Possible Bay Configurations

I. 30’ x 20’ – Joists traveling in 30’ direction
II. 30’ x 40’ – Joists traveling in 30’ direction
III. 30’ x 20’ – Joists traveling in 20’ direction
IV. 30’ x 40’ – Joists traveling in 40’ direction



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Gravity System

Hand Calculations

Possible Bay Configurations

I. 30’ x 20’ – Joists traveling in 30’ direction
II. 30’ x 40’ – Joists traveling in 30’ direction
III. 30’ x 20’ – Joists traveling in 20’ direction
IV. 30’ x 40’ – Joists traveling in 40’ direction

Layout	Decking	Joists	Girders
I	1.0C24	22K10	W18x35
II	1.0C24	22K10	W24x146
III	0.6C24	14K4	W24x68
IV	0.6C24	26K12	W24x76

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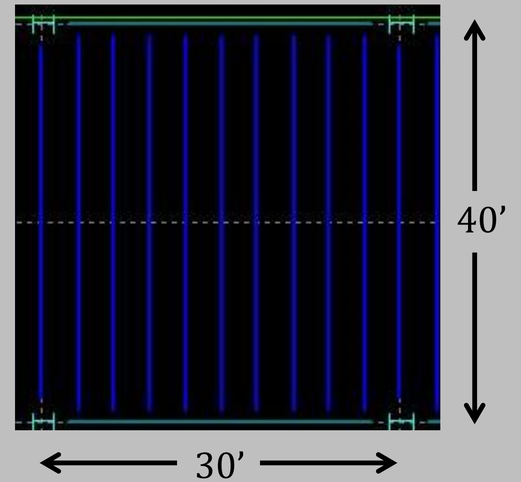
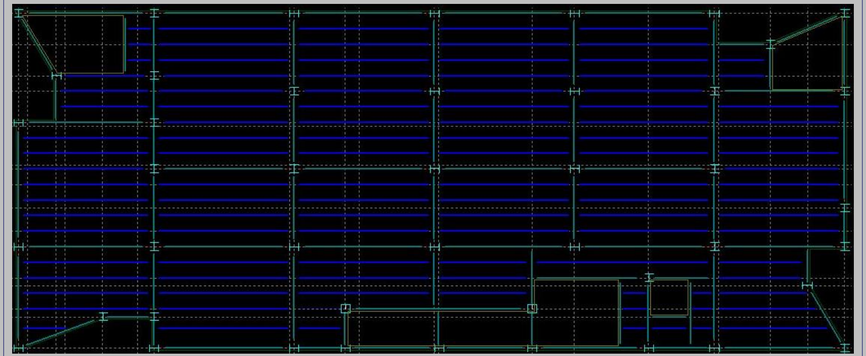
Layout	Bay Size	Walking Evaluation < 0.5 % g	Floor Stiffness < 9 Hz	Final Evaluation
I	30’x20’	0.47 % g	5.47 Hz	Pass
II	30’x40’	0.28 % g	3.54 Hz	Pass
III	30’x20’	0.38 % g	4.77 Hz	Pass
IV	30’x40’	0.58 % g	3.93 Hz	Fail

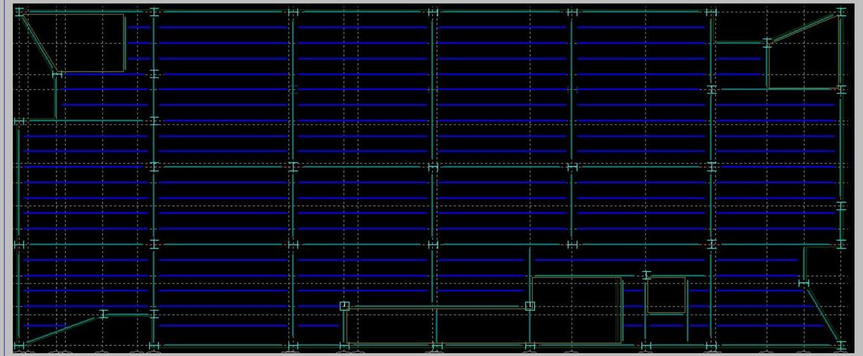


Gravity System – Final Redesign

Layout	Bay Size	Decking	Joists	Girders
I	30’x20’	1.0C24	22K10	W18x40



Layout	Bay Size	Decking	Joists	Girders
II	30’x40’	1.0C24	22K10	W30x124



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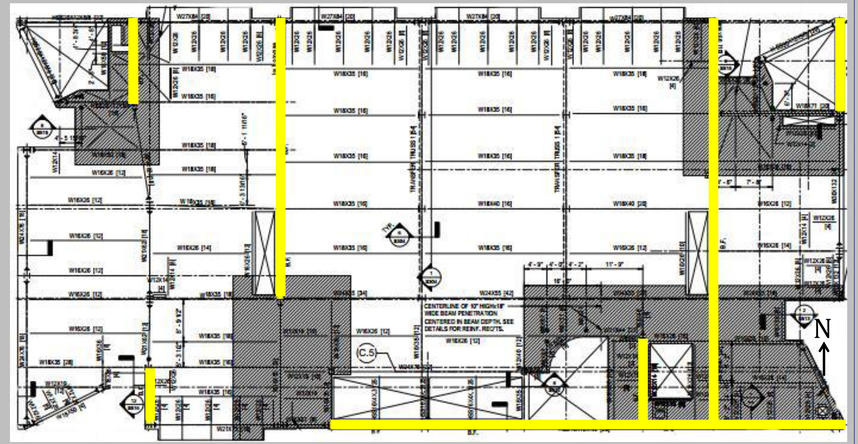
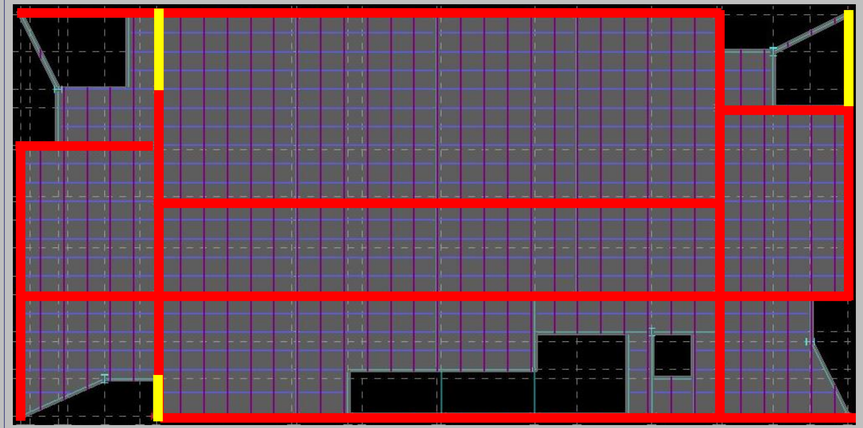
Lateral System

Existing Lateral System – Braced Frames



Proposed Lateral System – Moment Braced



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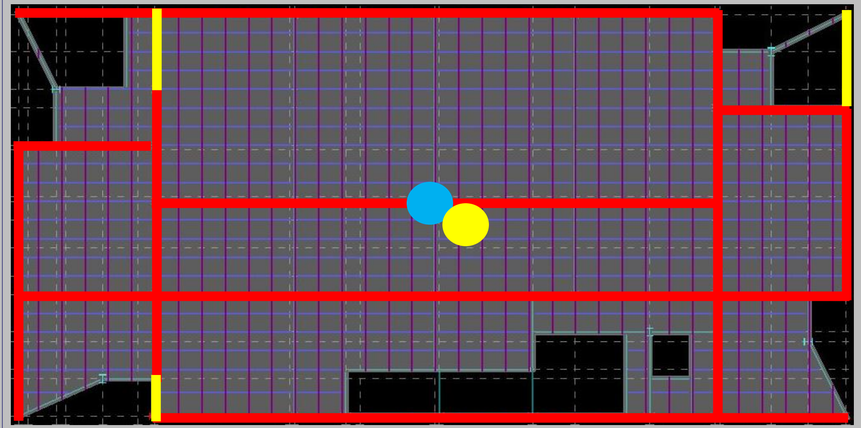
RAM Model

Center of Mass + Center of Rigidity

Center of Mass (88, 43.5) Center of Rigidity (91, 39)



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RAM Model

Center of Mass + Center of Rigidity

Drift Checks

Wind Loadings – Case 1 Controls

Seismic Loadings

Maximum Drifts

Loading	Drift	Allowable Drift
Wind – Case 1	0.42	0.44
Wind – Case 2	0.32	0.44
Wind – Case 3	0.32	0.44
Wind – Case 4	0.25	0.44
Seismic	0.62	2.9

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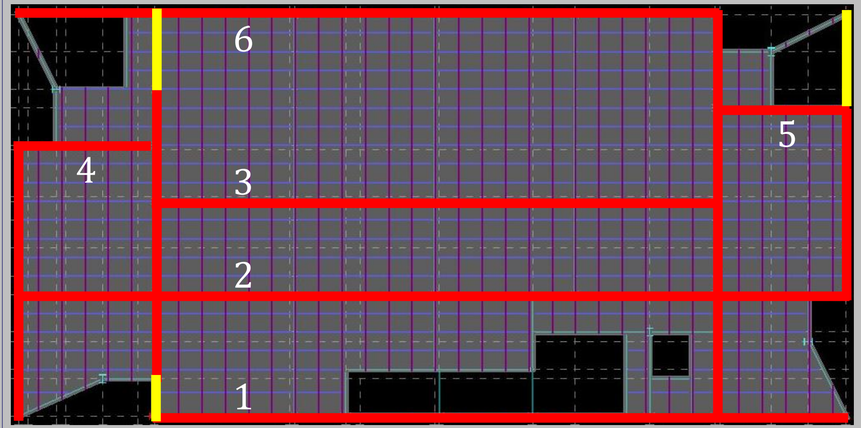
Frame Participation

Frame #	1	2	3	4	5	6
Avg. Load	20%	32%	20%	5%	5%	18%

Proposed Lateral System



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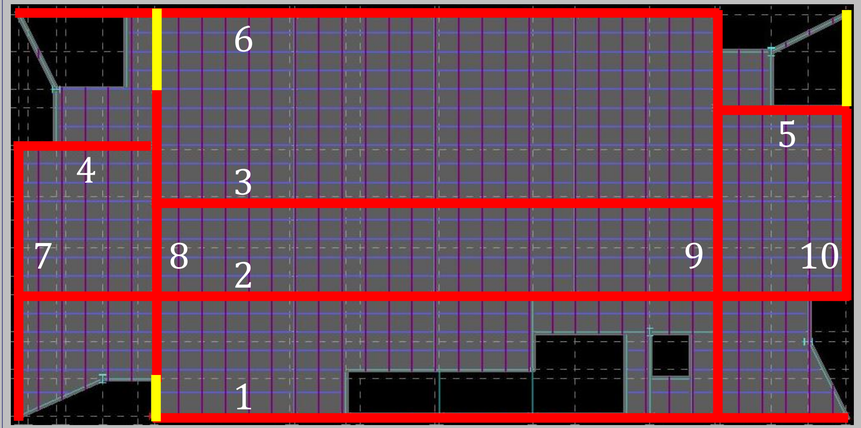
Frame Participation

Frame #	1	2	3	4	5	6
Avg. Load	20%	32%	20%	5%	5%	18%

Frame #	7	8	9	10
Avg. Load	5%	54%	15%	26%

Proposed Lateral System



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Cost & Schedule Analysis

{Breadth 1}

VCU SOM | Cost & Schedule Analysis | {Breadth 1}

Structural System Costs

Total Project Costs

Curtain Wall Changes
Additional Fireproofing

Schedule Comparison

Original System	
Concrete	$ 1.16
Conc. Placing	$ 0.25
Conc. Finishing	$ 0.14
Shear Studs	$ 0.16
Beams	$ 4.20
Girders	$ 11.72
Decking	$ 2.80
Fireproofing	$ 0.81
Total ($/SF)	**$ 21.23**

Redesigned System	
Concrete	$ 1.25
Conc. Placing	$ 0.18
Conc. Finishing	$ 0.67
K-Series Joists	$ 3.41
Girders	$ 8.17
Decking	$ 2.22
Fireproofing	$ 1.70
Total ($/SF)	**$ 17.61**

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Cost & Schedule Analysis

{Breadth 1}

Structural System Costs

Total Project Costs
Curtain Wall Changes
Additional Fireproofing

Schedule Comparison

System	Floor-to-Floor	Ceiling Ht	Total Height
Original	14’ – 8”	11’ – 0”	196’ – 0”
Redesign Option 1	14’ – 8”	10’ – 6”	196’ – 0”
Redesign Option 2	15’ – 2”	11’ – 0”	202’ – 6”

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Cost & Schedule Analysis

{Breadth 1}

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Structural System Costs

Total Project Costs

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Schedule Comparison

System	Original	Redesign – A	Redesign – B
Decking	Meets 2 HR	Meets 2 HR	Meets 2 HR
Steel	Spray	Spray	Factory Applied+Spray
Ceiling	Non-Rated	Non-Rated	Rated
Sprinkler	Yes	Yes	No
Price Increase	–	$ 0.92/SF	$ 1.20/SF

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Cost & Schedule Analysis

{Breadth 1}

Structural System Costs

Total Project Costs
Curtain Wall Changes
Additional Fireproofing

Schedule Comparison

Task	Original Duration	Redesign Duration
Steel Erecting + Detailing	122 days	114 days
Deck Pour/ Fireproofing	89 days	93 days

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Architectural Impacts

{Breadth 2}

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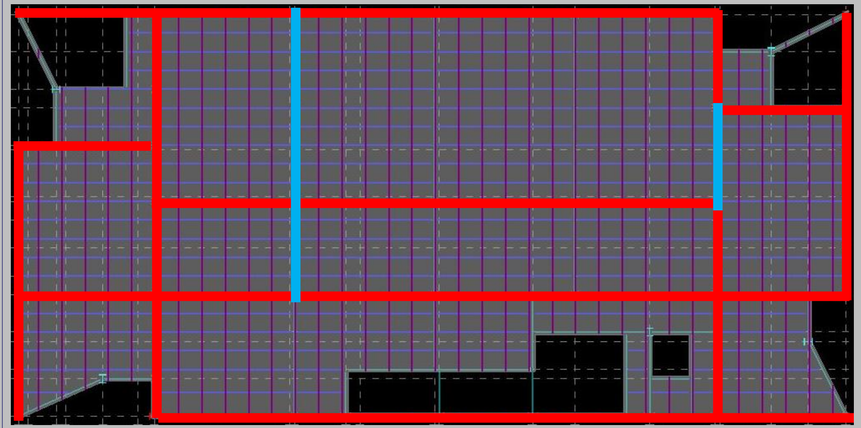
Architectural Impacts

{Breadth 2}

Creating an Open Environment

Fireproofing Redesign

- Occupancies
- Additional Fire Barriers
- Removal of Sprinklers



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Architectural Impacts

{Breadth 2}

Creating an Open Environment

Fireproofing Redesign

Occupancies
Additional Fire Barriers
Removal of Sprinklers

Floor	Main Occupancies	Additional Fireproofing	Sprinklers Removed
1 – 3	A & B	–	–
4	B	65 LF	120
5 – 8	A & B	300 LF	90
9	B	25 LF	150
10	B	65 LF	120
11	A & B	150 LF	100
12	A & B	55 LF	100

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Conclusions

Increase efficiency of structural system

Save both time + money

In line with VCU SOM reinvented curriculum, create open environments

Designed viable alternate structural system

Non-composite deck + K-series joists + girders

Controlled lateral deflections

Decreased eccentricity

Reduced project costs + schedule

Impacted Architecture Positively

Eliminated bracing

Increased Fireproofing Options

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Acknowledgements

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Professor M. Kevin Parfitt

Family & Friends

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Comments

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