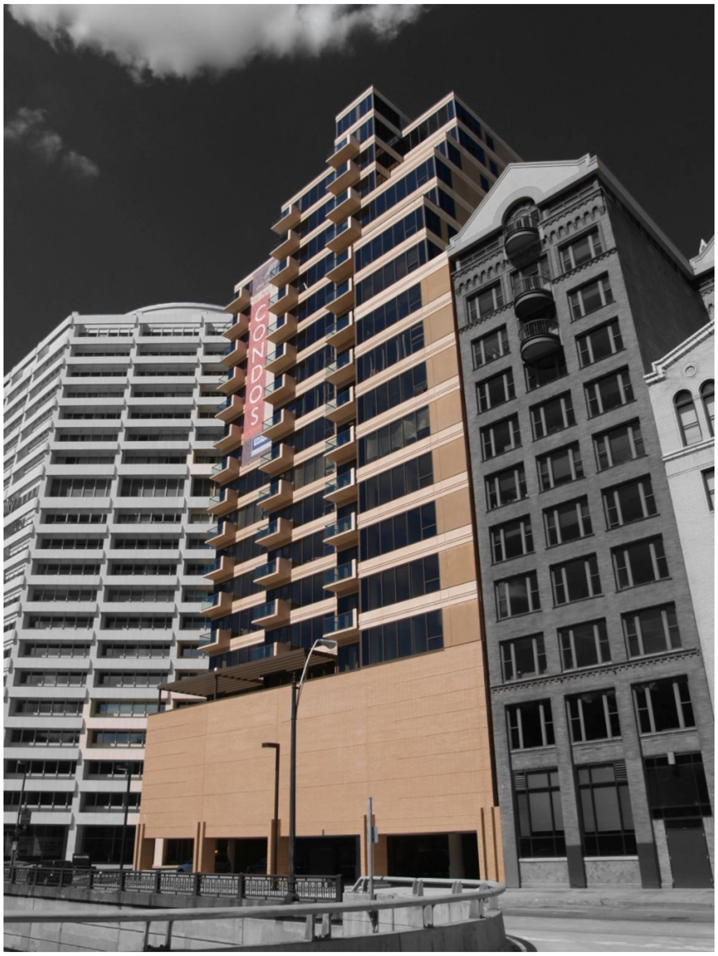
151 First Side

Thesis Proposal - Revised

January 18th, 2008



William J. Buchko

Structural Option

AE 481w – Senior Thesis
The Pennsylvania State University

Thesis Advisor: Kevin Parfitt

Table of Contents

Executive Summary

Report Summary:

151 First Side is an 18 story condominium project located on 151 Fort Pitt Boulevard in Pittsburgh, PA. The first three floors are a parking garage with the above floors housing residential space. The primary floor system is a proprietary Hambro MD2000 composite floor joist system. Lateral stability is achieved using a combination of braced frames and moment connections.

For my thesis I will be proposing a conventional composite steel floor system. I will also research whether a lateral system of all moment connections or all braced frames would be more economical and easier to construct. The final design will provide equal or better strength and serviceability while lowering the final cost.

In addition to redesigning the structural system I will also be looking at two areas of breadth studies. The first breadth study is an acoustical analysis of both the typical residential level as well as the rooftop mechanical unit. The second breadth study will be a detailed cost analysis and schedule impact of my proposed floor system and framing as compared to the current system.

The acoustical analysis is being performed due to an expressed interest in sound transmission by the owner. The current system will be compared to the proposed system and, if necessary, further sound protection will be designed.

Since 151 First Side was designed with speed and cost as two major criteria, I will be analyzing the schedule and cost information. With the proposed structural changes I hope to lower the material cost, labor cost, and overall length of the project. I will also be looking at what impact, if any, the proposed acoustic solutions may have on each of these.

Structural System

Foundation:

The foundation was designed based on soil reports prepared by Engineering Mechanics, Inc. and Ackenheil Engineering, Inc., dated April, 2002 and July 1, 2005 respectively. Due to the close proximity of the Monongahela River pressure injected auger cast piles, 18” in diameter were used. Pile tips were placed at an elevation of 674’-0”, which gives an average length of 52’. Each pile has a capacity of 120 tons. Pile caps are made of concrete with a 28 day strength of f'_c = 3000psi.

Slab on Grade:

The sub-basement and basement floors consist of slab on grade at elevations 725’-0” and 728’-0” respectively. Slabs are made from 5” of concrete with a 28 day strength of f'_c = 4000psi and are reinforced with 6x6 w2.1 x w2.1 welded wire fabric. Concrete was placed above 4” of AASHTO 57 well graded compacted granular stone.

Structural Frame:

The structural framing is made of steel W shapes with a combination of braced frames and moment connections for lateral support. Beams range from W10 to W16 with the most common size being a W14x61. The columns are W12 shapes with weights ranging from 40 to 336 pounds per linear foot. Common column splices occur at every second floor.

Floor and Roof System:

The parking levels on the first three stories as well as the terrace level have poured concrete floors. All parking floors are 4” of light weight concrete on a 2” 20ga. galvanized composite metal deck with the exception of some highly loaded areas of the ground floor in which there is a 6” slab. The 4” sections on the parking levels are reinforced with #4 rebar spaced at 12” in both the bottom and the top of the slab with the top bars continuing for ¼ of the span length past the supports. The 6” sections contain 6x6-W2.9xW2.9 welded wire fabric while the terrace level has 6x6-W1.4xW1.4 welded wire fabric for its reinforcement.

The residential and mechanical levels, as well as the roof, contain an MD200 composite floor joist system provided by Hambro. A typical floor plan can be found in figure 1. There is a 3¼" thick slab made from concrete with a 28 day strength of f'_c=4000psi. Reinforcing within the concrete is a 6x6-W2.9xW2.9 welded wire mesh. The concrete is supported by 22ga. 1½" galvanized steel deck. Joist depth is 16" unless otherwise noted. The top chord is an "S' shape piece of cold-rolled, ASTM A 1008, Grade 50, 13ga. steel which works as both a compressive member as well as a shear connector while the bottom chord is made of two steel angles. Both chords have a minimum F_y=50,000psi. The web is formed from 7/16" hot-rolled steel bars with an F_y=44,000psi. The roof is also topped with a waterproof membrane.

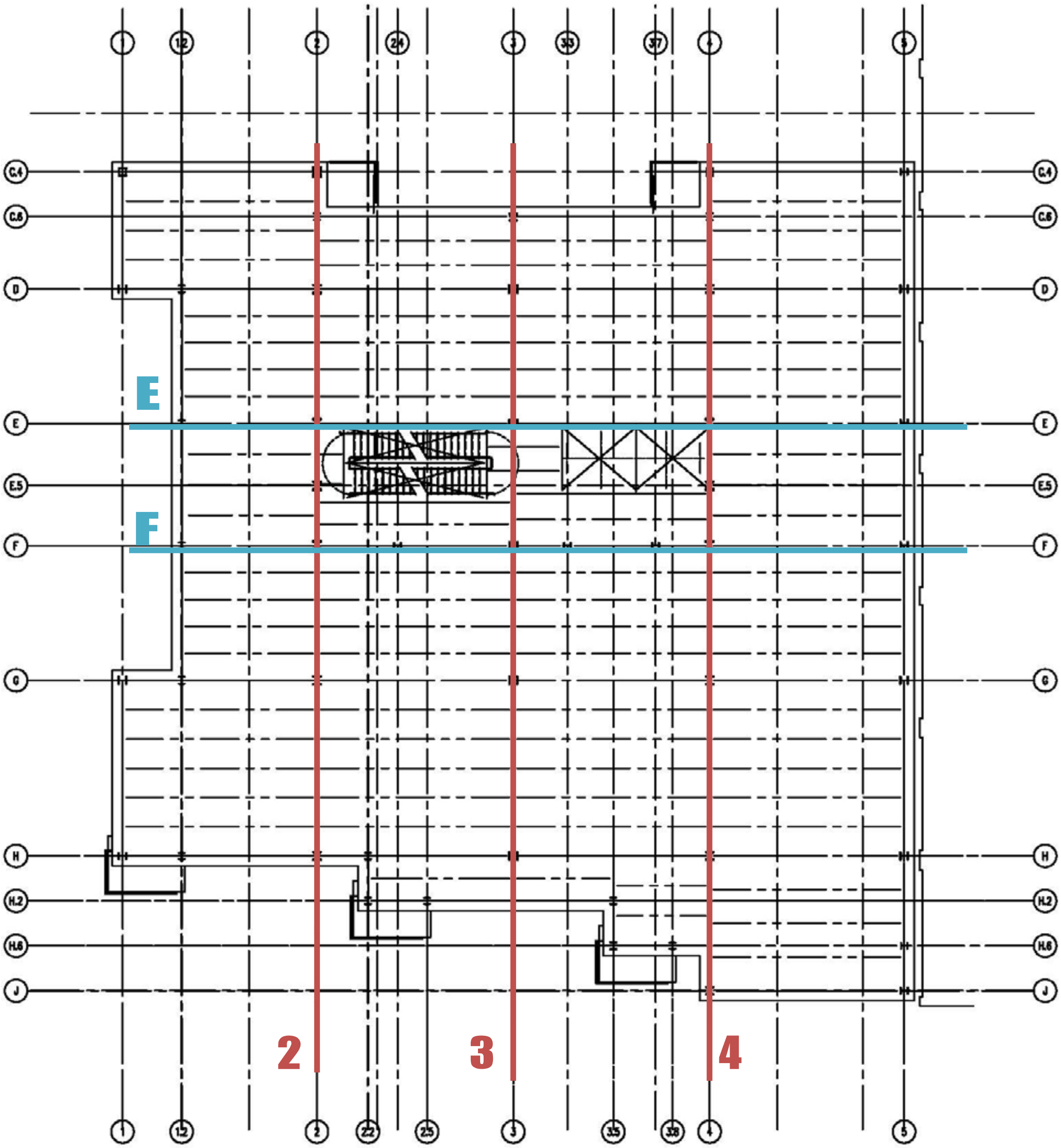


Figure 1

Lateral System:

The lateral system is composed of both braced frames as well as special moment frames. Lateral bracing is provided on column lines E and F (Figure 2) and column lines 2, 3, and 4 (Figure 3). Each of these column lines contain both moment connections and braced frames made of W12's or back to back channels.

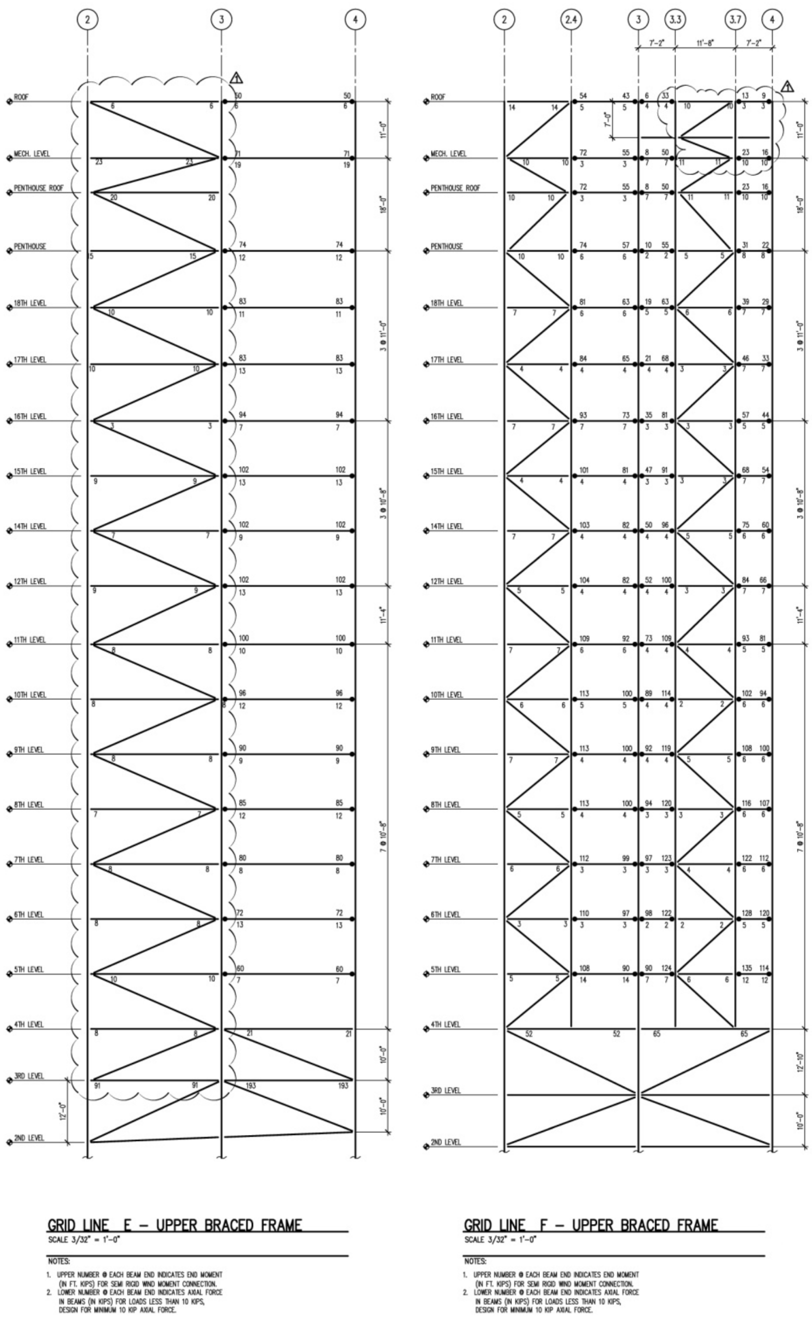


Figure 2

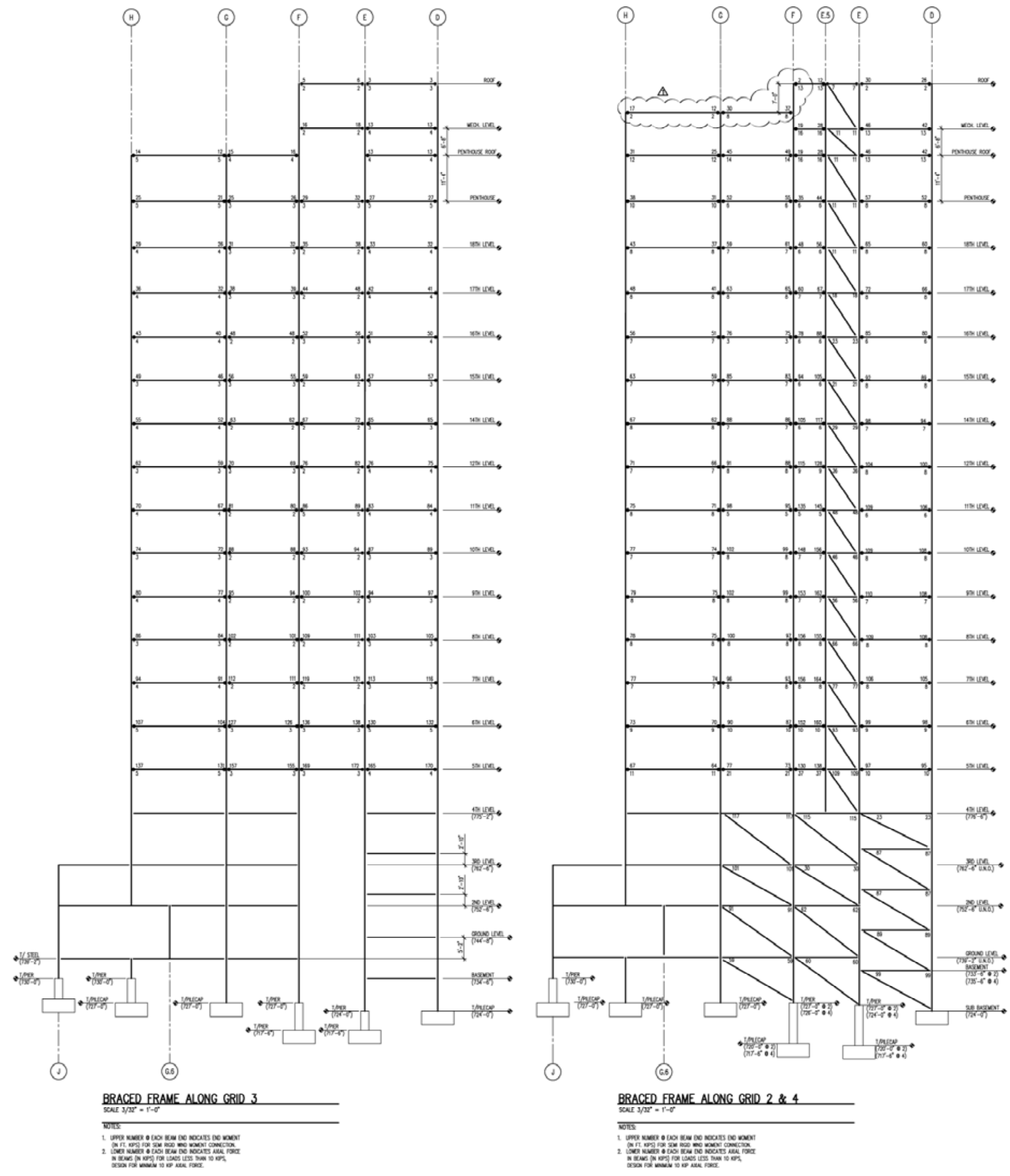

BRACED FRAME ALONG GRID 3
SCALE 3/32" = 1'-0"
NOTES:
1. UPPER NUMBER @ EACH BEAM END INDICATES END MOMENT (IN FT. KIPS) FOR SEMI RIGID WIND MOMENT CONNECTION.
2. LOWER NUMBER @ EACH BEAM END INDICATES AXIAL FORCE IN BEAMS (IN KIPS) FOR LOADS LESS THAN 10 KIPS, DESIGN FOR MINIMUM 10 KIP AXIAL FORCE.
BRACED FRAME ALONG GRID 2 & 4
SCALE 3/32" = 1'-0"
NOTES:
1. UPPER NUMBER @ EACH BEAM END INDICATES END MOMENT (IN FT. KIPS) FOR SEMI RIGID WIND MOMENT CONNECTION.
2. LOWER NUMBER @ EACH BEAM END INDICATES AXIAL FORCE IN BEAMS (IN KIPS) FOR LOADS LESS THAN 10 KIPS, DESIGN FOR MINIMUM 10 KIP AXIAL FORCE.

Figure 3

Problem Statement

151 First Side was designed with the proprietary Hambro floor system due to the large bays and quick installation. The lateral frame also has an unconventional combination of concentrically braced frames and moment connections due to architectural changes late in the design. While these decisions may have provided short-term benefits, I feel that these may not be the most cost-effective choices. Through the exploration and use of conventional systems, I intend to propose a value engineered design that will decrease overall cost while remaining sensitive to non-structural requirements.

Problem Solution

In the second technical report, it was determined that a composite steel floor system would be a viable option with the possibility of cutting costs. This type of system has the potential to cost less in raw materials, as well as provide savings in fireproofing. During my research for the third technical report, I found that the building was initially designed with concentrically braced frames as the sole lateral support. It was later decided by the architect that the planned location of braced frames would be too intrusive in the open-floor plan. Because of this, the braced frames in those locations were changed to moment frames. While converting the previous design to the current design may have provided economical benefits in terms of engineering man hours, I feel that with further study a system can be found that will provide the required lateral stability while reducing material and installation costs.

Solution Method

All design work will be performed using United Steel Deck manuals, the 13th Edition of the AISC Steel Design Manual, and computer modeling. My original RAM Structural System model showed an unacceptably large lateral drift due to deflections at the second floor transfer girders. Due to the difficulty in obtaining satisfactory results within RAM Structural System, a second computer model will be created and compared and computer output will be verified by spot checks where applicable. All loads will be based on those that have been previously calculated and will be compared to the design engineer's values and modified accordingly. The floor system will be designed for both strength and serviceability criteria. The lateral system will be analyzed using both wind and seismic forces.

Breadth Topics

In addition to my proposed structural redesign I will consider its affect on other systems in the building. I will also be exploring some of the primary concerns of the owner and engineer in regards to serviceability. From these two topics, I have decided on two topics for my breadth studies.

My first breadth study will be an acoustical analysis. The current floor system design had an extra ½"of concrete added to help in both sound transmission and vibration. I will be looking at the effects of my proposed floor system on the acoustical properties of the residential areas. I will also look at possible ways to reduce the noise from the rooftop mechanical unit as the most common complaint from people touring the building is that sound carries from the unit to the 3,000 SF outdoor terrace of the Penthouse.

The second area I will investigate is within the construction management field. Since this project was designed with cost and schedule as major components of the design process, I will be analyzing the effect of my proposals on both of these criteria. Using RS Means, Primavera, and information obtained by the contractor and owner, I will perform a cost analysis and schedule impact between the current system and the proposed floor system, including acoustical additions.

Schedule Tasks

Structural

S1: Revise RAM Structural System model and create Staad model

S2: Create Staad model

S3: Revise lateral loads

S4: Design steel composite floor system with NWC

S5: Design steel composite floor system with LWC

S6: Design moment frame lateral system

S7: Determine possible braced framing locations

S8: Design braced frame lateral system

S9: Compare and choose best composite floor system

S10: Compare and choose best lateral system

Acoustical

A1: Research current acoustical properties

A2: Determine acoustical properties for typical floor

A3: Design any needed acoustical solutions

A4: Research noise level of mechanical system

A5: Design sound barrier for mechanical system

Construction Management

C1: Research current cost and scheduling

C2: Research expected cost and scheduling for new floor and lateral system

C3: Research cost and scheduling for acoustical considerations

Miscellaneous

M1: Edit Final Paper

M2: Publish Final Paper

M3: Revise web site

M4: Prepare Final Presentation

M5: Final Presentation

Schedule Chart

Week	Dates	Tasks
Christmas Break	Dec 24 - Jan 11	A1, A4, C1, M3
1	Jan 14 - Jan 18	S1, S2
2	Jan 21 - Jan 25	S1, S2, S3
3	Jan 28 - Feb 1	S3, S4, S5
4	Feb 4 - Feb 8	S6
5	Feb 11 - Feb 15	S7, S8
6	Feb 18 - Feb 22	A2, A3, S9
7	Feb 25 - Feb 29	A2, A3, S10
8	Mar 3 - Mar 7	A5
Spring Break	Mar 10 - Mar 14	M3
9	Mar 17 - Mar 21	C2
10	Mar 24 - Mar 28	C3
11	Mar 31 - Apr 4	C3, M1
12	Apr 7 - Apr 11	M2, M4
13	Apr 14	M5