4.0 SITE ANALYSIS

4.1 EXISTING CONDITION

4.5 HISTORIC PRESERVATION

4.6 PREDOMINANT VIEWS

4.7 PEDESTRIAN MOVEMENT

4.8 VEHICULAR MOVEMENT

4.9 ACOUSTICS

This section describes the acoustic criteria for the project and preliminary constructions required to achieve the criteria.

4.9.1 KEY ACOUSTIC ISSUES AT DD

A summary of the major acoustic issues as the end of design development are:

- The mechanical room with pumps and heat pumps is located beneath the lecture hall. The portion of structure that is directly adjacent is very small, however the sound transmission to the Lecture Hall will also travel diagonally through the structure and the entire ceiling of the pump room must be lined with a double layer gypsum ceiling that is resiliently hung and de-coupled from the structure. The need for this is driven by the high and tonal noise level of the equipment and the proximity of the room to the Lecture Hall. This room has moved since SD to its current location below the Lecture Hall.
50%CD Update: pump room includes sound isolating ceiling.
100%CD Update: to maximize space for piping in pump room, full sound isolating ceiling has been changed to a fully-sealed resiliently-hung gypsum/plywood soffit in the area of the pump room underneath Lecture Hall, acceptable given the additional mass of the radiant floor slab above.

- The north facing façade will transmit noise from Queensboro Bridge to the conference rooms. These 2 conference rooms will be less formal than the conference rooms on the south façade which will be quieter and better suited for video conferencing.
50%CD Update: An upgrade to the external glazing to these rooms has been recommended to 1/2-in lam / 1/2-in airspace / 3/8 glass.
100%CD Update: External glazing in these rooms has been updated to incorporate the acoustic requirements.

- The Lecture Hall has specialty acoustic window assemblies including:
  - A double-glazed system at the lobby to achieve STC50.
  - A sliding wall system with framed glass on the inside of the insulated façade glazing.

  50%CD Update: The external inner glazing does not extend full height, providing no benefit for controlling external noise ingress. As a result it is predicted that low frequency noise from external traffic activity will be audible within the lecture hall, levels are predicted to be comparable to Millstein Hall.

- Floors above learning spaces, conference rooms the lecture hall and other noise sensitive spaces of the building will require footfall impact-noise control. Carpet is used in several areas to mitigate and an impact layer will be required in a few areas that have hard surface floors: above the Lecture Hall and the above the lower level Seminar Rooms.
50%CD Update: The hard floors above the lecture hall and both levels of seminar rooms include a resilient impact layer to help mitigate footfall.

- Slab thicknesses have been designed for acoustic performance along with the structural design with cost consideration. Criteria and/or constructions have changed since SD based on changes in finishes and to comply with budget.

- Sound absorbing treatment will be used in seminar rooms, conference rooms, the lecture hall, collaboration, studios, lounges, foyer, pre-function, huddle rooms, and the project space to increase speech intelligibility and acoustic comfort.

- Sound absorbing treatment will be used in workspaces to control reverberant noise build-up. This is achieved by using perforated metal structural deck (Epic deck as basis).

  The lower level entrance of the Lecture Hall does not have a sound-light-lock vestibule. The options include a) an acoustically rated steel door with actuators b) adding doors to create a sound light lock vestibule and c) use full perimeter seals on solid wood door and accept some noise ingress into the Lecture Hall. Option C would be comparable in performance to Millstein Hall Auditorium at Cornell Ithaca. Morphosis has reviewed and deemed option C acceptable.
  100%CD Update: We understand that the upper level vestibule entrance of the Lecture Hall has been changed to utilize frameless doors. Without a proper door frame to seal against, it will be difficult to achieve a good acoustical performance from these doors, even with compression seals on the door itself. It is expected that sound from the lobby area will be audible in the Lecture Hall even with both doorsets closed due to flanking around the doors. If frameless doors remain, compression seals are recommended on sides and top, and automatic drop seals on the bottom of all doors in the vestibule. Reverse cam-lift hinges may be necessary to allow the door to open and close with a compression seal on top. However, given the frequency of door use, it is likely that significant wear will occur on the seals and the nearby surfaces as a result.

4.9.2 OUTDOOR NOISE SUMMARY

We measured the daytime outdoor ambient noise on the existing site on July 6, 2012. The major source of noise is the Queensboro Bridge which has constant road traffic including heavy trucks. It is located about 350 feet from the site.

In general, the site levels are quieter than a busy Manhattan street but significantly louder than a city park. The loudest location measured was at the northwest corner of the site, closest to the bridge.

There are occasional ships that pass on the East River – noise from these events would be intermittent and the measurements did not include ship horns or motoring vessels.

New campus buildings will change the outdoor noise on site. The First Academic Building and other site buildings will block noise from the Queensboro Bridge and have the potential to create quieter outdoor spaces in some areas. Noise plots of a possible site scheme are provided in the following figures.

For reference, many international standards recommend that background noise in outdoor areas used for recreation or relaxation should be 55dB(A). Only small portions of the site meet this requirement. Other areas in NYC have the following typical background noise (L_{90}) ranges:

Typical Busy Manhattan Street	65 – 75dB(A)
Bryant Park	60 – 65dB(A)
Central Park	50 – 60dB(A)
Cornell FAB Site	52 – 70dB(A)
Recommend Level for Parks	55dB(A)

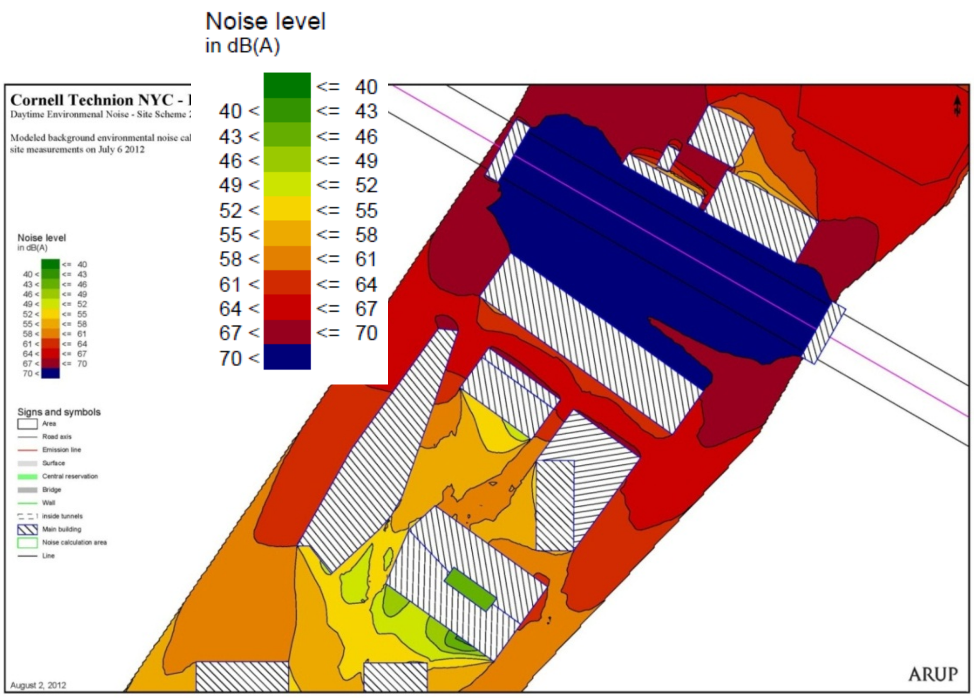


Figure 1

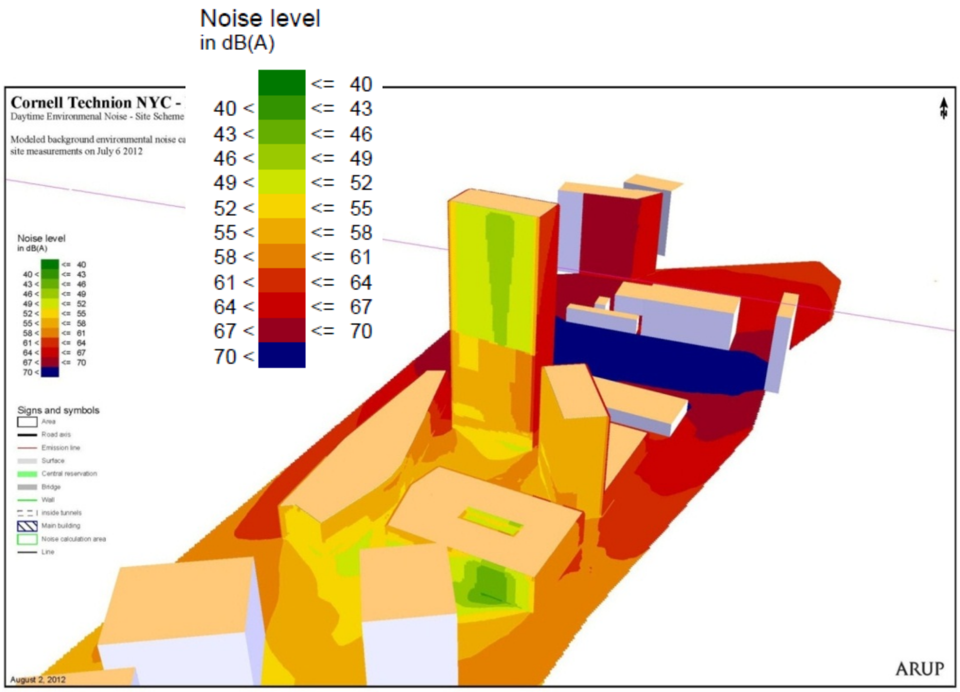

Noise level
in dB(A)
<= 40
40 < <= 43
43 < <= 46
46 < <= 49
49 < <= 52
52 < <= 55
55 < <= 58
58 < <= 61
61 < <= 64
64 < <= 67
67 < <= 70
70 <
Cornell Technion NYC -
Daytime Environmental Noise - Site Scheme
Modeled background environmental noise ca
site measurements on July 6 2012
August 2, 2012
ARUP

Figure 2

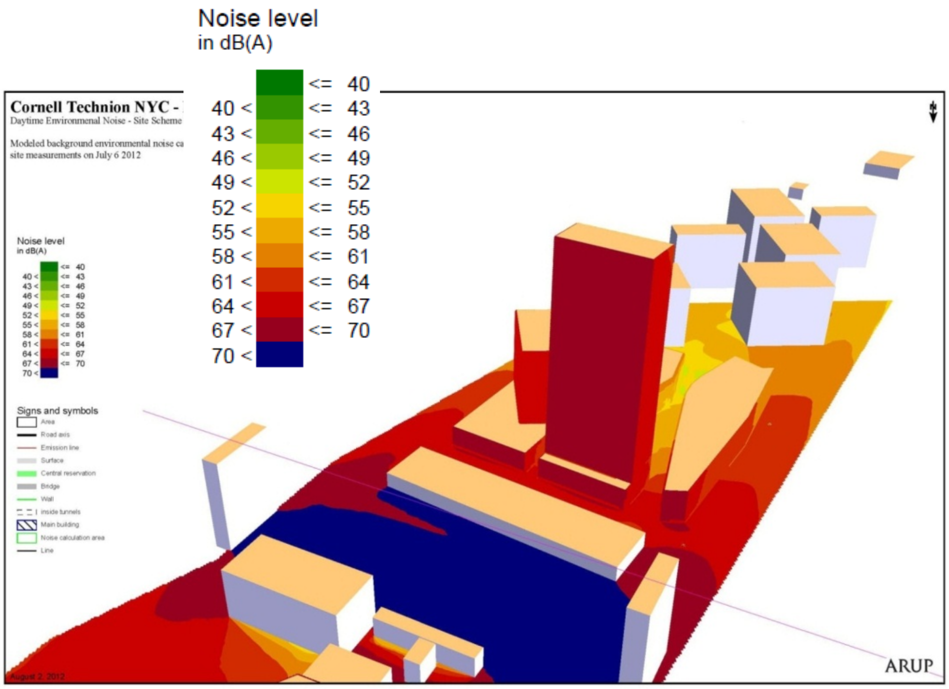

Noise level
in dB(A)
<= 40
40 < <= 43
43 < <= 46
46 < <= 49
49 < <= 52
52 < <= 55
55 < <= 58
58 < <= 61
61 < <= 64
64 < <= 67
67 < <= 70
70 <
Cornell Technion NYC -
Daytime Environmental Noise - Site Scheme
Modeled background environmental noise ca
site measurements on July 6 2012
Noise level
in dB(A)
Signs and symbols
ARUP

Figure 3

Based on our modeled scheme, we anticipate the following levels in outdoor areas and at 1-ft from the facades:

	Outdoor L_{90} Background Noise, dB(A)*	Note
Courtyard to East	55 – 61	Noise from Queensboro will be heard as steady noise. The noise *level* will be comparable to an urban park (e.g. Bryant Park in NYC) – the landscaping should consider addition of natural sounds such as wind in trees.
South Café Seating	52 – 61	Seating areas without line of site to Queensboro Bridge are at the quieter end of this range and would be acceptable for an outdoor café, where noise from the café mixes with the environmental noise at comparable levels.
North Façade at Conference Rooms	67 – 70	This façade has the loudest incident noise from Queensboro bridge.
North Façade at Collab	67 – 70	This façade has the loudest incident noise from Queensboro bridge.
West Façade at Lecture Hall	61 – 64	Refer to following section on Façade design. The Lecture Hall has higher façade acoustic performance requirements than the rest of the building.
West Façade at Seminar Rooms	64 – 67	
West Façade at Office Zones	61 – 67	
East Façade at North Huddle Rooms	58 – 64	
East Façade at South Office Zone C	55 – 58	
South Façade at Conference Rooms and Multipurpose	55 – 58	This façade has the quietest incident noise from Queensboro bridge.

*Background noise is the level of constant noise heard on site, it is used to qualify outdoor noise environments.

4.9.3 BUILDING FAÇADE ACOUSTICS

Based on the external noise levels listed above, we recommend the following acoustic performance for the façade.

	Sound Isolation Requirement (STC)	Basis (Minimum) Construction
Typical Exterior Vision Panels (Glass + Framing)	37	3/8” – 1/2"a.s – 1/4"
Typical Exterior Vision Panels At Lecture Hall	40	3/8” – 1/2"a.s – 1/2"lam
Typical Exterior Opaque Elements	50	Metal Exterior Panel 1x5/8” sheathing Min 6” insulation 1x5/8” gyp interior
Internal movable wall at Lecture Hall façade (but not part of façade system):	17	Movable wall system with framed glass - min 3/8” laminated pane spaced a minimum of 8 inches from the exterior wall system on the inside of the building. **50%CD Update:** This is not included in the design.

Flanking Noise

Where acoustically rated partitions intersect with the façade, there are requirements to reduce flanking noise transmission through elements such as vertical mullions, slab edge joints. The following requirements apply to the intersections.

	Façade Flanking Noise Performance ISO10848-2*	Basis Construction
Huddle Rooms at Façade	45 dB	Airtight vertical mullion intersections with walls.
Conference Rooms	50 - 55 dB	Airtight vertical mullion intersections with walls. Or punched windows only.
Seminar Rooms at Curtainwall	50 – 55 dB	Airtight vertical mullion intersections with walls. Mullion coverplate design**.
Lecture Hall	60 – 65 dB	Airtight storefront system shall be designed by the CW contractor to not degrade the façade performance by STC37 at intersections.
All other areas (Base Mullion and Design)	40 dB	Airtight vertical mullion intersections with walls.
All areas (Base Slab Edge Condition)	50 dB	Airtight system with minimum 3psf insulation in full slab edge cavity with minimum thickness equal to the slab thickness. Fully packed from inner face of façade to the slab edge.

* Acoustics –Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms – Part 2: Application to light elements when the junction has a small influence.

** One option is to use the “Mull-it-over”product – see figures on following page. A second option is to develop and extrusion detail that is included in the curtainwall scope.

Figure 4

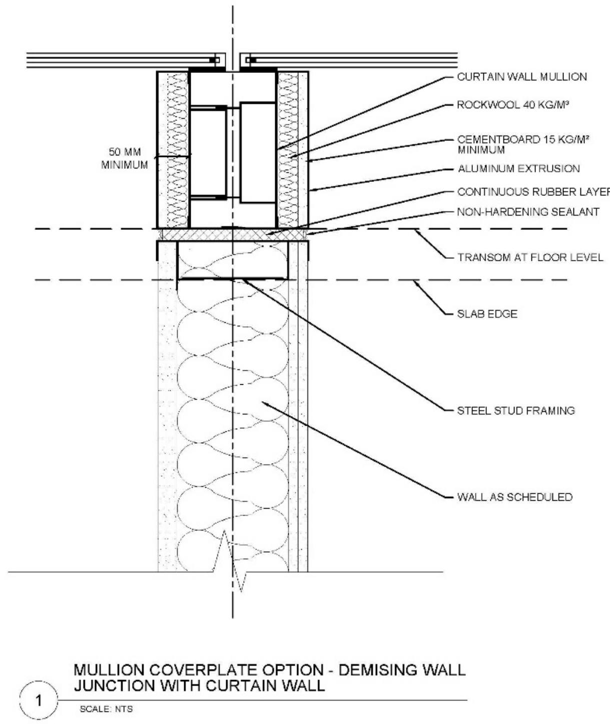


Figure 5

For division between level 1 Seminar Rooms

50%CD Update: The conference room and seminar room mullion detail does not include a cover plate or packed mullion detail. The flanking noise performance is not expected to meet the targets set out in the table above by approximately 5 – 10 dB.

4.9.4 STRUCTURAL DESIGN

<u>Exposed Structure</u>

There will be exposed structure in many areas of the building. The acoustic challenges are:

- Impact Isolation: Footfall noise will transmit through exposed structure (polished concrete floors, exposed metal deck). Where exposed concrete floors are located above acoustically sensitive areas, an impact reduction underlayment should be installed between the structural slab and a topping slab. Impact sound control is recommended for seminar rooms, meeting/conference spaces, office zones, collaboration spaces, the masters studio, project space, café, pre-function, lounges and circulation spaces.

- Reverberation control: Spaces that require reverberation control, e.g. office zones, seminar rooms, collaboration space, the masters studio, project space, the lecture hall and meeting spaces, will require acoustic treatment on the ceiling.

- Mechanical Noise Control: Spaces with exposed mechanical equipment, pipe and duct will have higher noise levels than those with enclosed equipment. Furthermore, the noise of the mechanical equipment will be more localizable. The acoustic impacts would include larger duct sizes and/or oval/round ducts in seminar rooms and conference rooms.

Airborne Sound Isolation

The structural slabs must sufficiently attenuate airborne sound between vertically adjacent spaces. The structural design basis is concrete composite slabs formed from profiled steel formwork. The slabs should have the following minimum weights:

Slabs:	Sound Isolation Rating	Minimum Mass	Basis Construction (min)
Above B1 Mechanical Rooms	STC55 (Structure Only) STC65 (Structure + Ceiling) **100% CD Update: STC60 (Structure Only)** **STC70 (Structure + Ceiling)**	90psf **100% CD Update: >100psf**	3-in deck with min 5.5-in pour **100% CD Update: 6-in radiant floor (lightweight concrete)** This assumes continuous hung ceiling (2 layers 5/8" GWB on hangers) **100% CD Update: Ceiling has been restricted to soffit under Lecture Hall area. Assumes 1 layer 5/8" GWB and 1 layer 3/4" plywood on spring hangers.**
Above Auditorium	STC60 (Structure Only)	>100psf	3-in deck 4.5-in pour Resilient layer 3.5-in topping pour
Above L0Seminar Rooms	STC60 (Structure Only) STC62	>100psf	3-in deck 5.5-in pour Resilient layer 3.5-in topping pour

Slabs:	Sound Isolation Rating	Minimum Mass	Basis Construction (min)
	(Structure + Ceiling)		This assumes perforated or mesh metal system with sound absorbing treatment behind.
Above Seminar Rooms on Ground Floor	STC50 (Structure Only) STC55 (Structure + Ceiling)	75psf	3-in deck 4.5-in pour This assumes a continuous hung ceiling in the seminar rooms with sound absorption applied to the underside of the ceiling.
Below Roof Mech Penthouse and Electrical Rooms	STC55 (Structure Only)	90psf	Minimum 3-in deck with min 5.5-in pour Assumes exposed structure below.
All Other Areas	STC50 (Structure Only)	75psf	3-in. deck 4.5-in pour Assumes exposed structure below.

Our preliminary criteria listed above are based on transmission of typical mechanical noise levels of the specific equipment scheduled in the building.

Sound Absorption

- The project will require sound absorbing finishes in most areas of the building to control reverberant noise. Morphosis has proposed approach of using sound absorbing metal deck throughout the building. This approach is acoustically acceptable with the following basis performance:

Basis Product	Sound Absorption Coefficient per 1/1 octave						NRC
	125	250	500	1k	2k	4k	
Epic Metals Epicore 3.5A	0.21	0.86	0.73	0.93	0.75	0.71	0.80

Allowable deviation in each band is +/- 0.10, and the total NRC +/- 0.05.

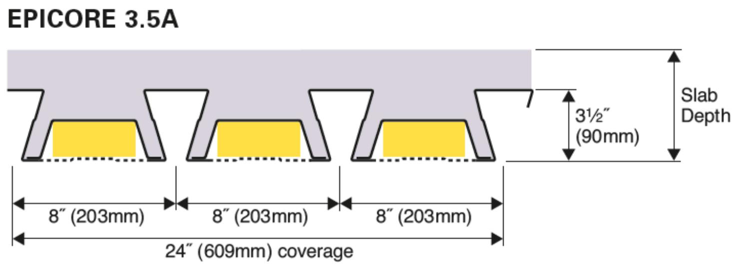


Figure 6

Architectural details will need to be developed to seal partitions to the deck, where acoustic isolation is required between spaces.

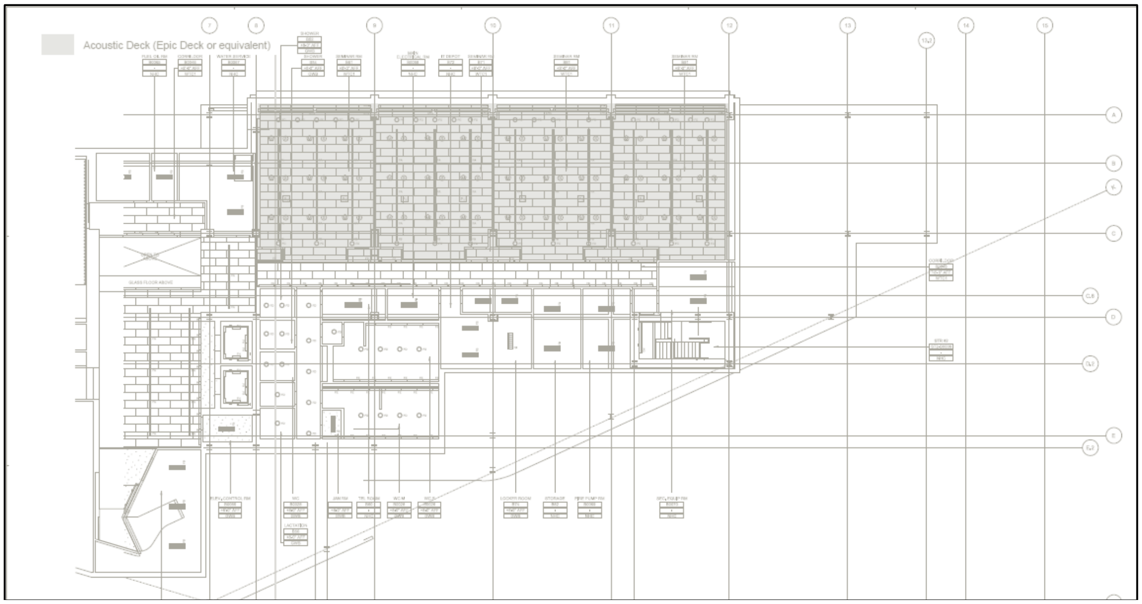
50%CD Update: Architect confirmed use of Epicore.

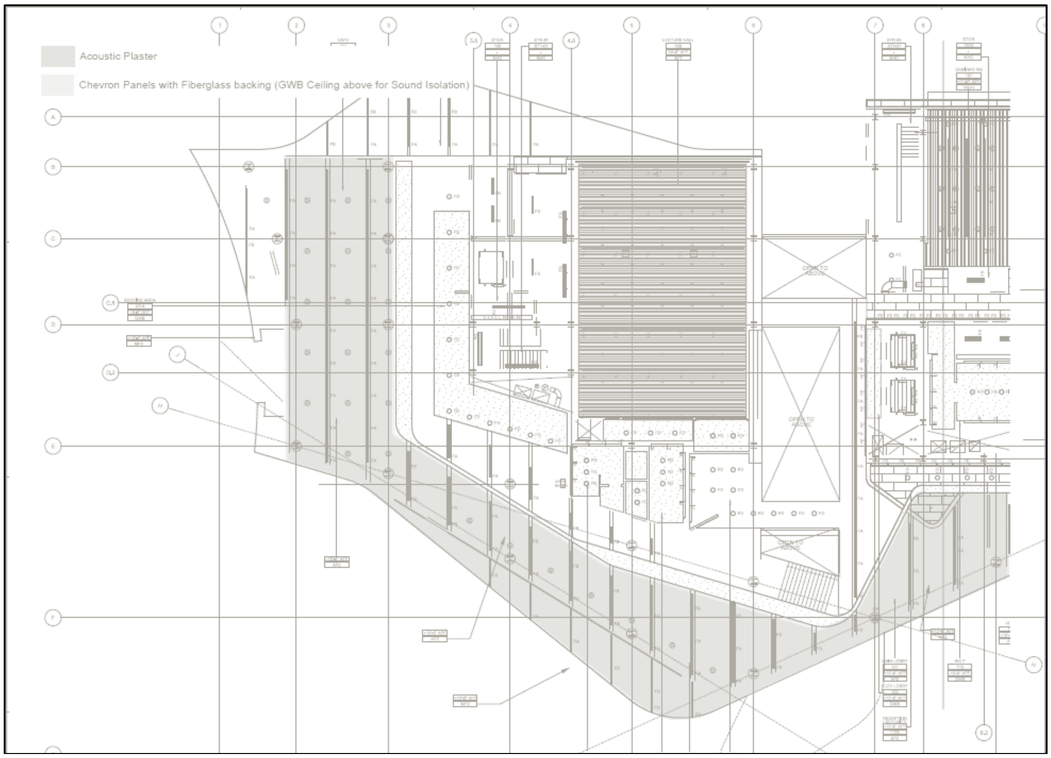
Alternatively, some manufacturers offer cellular deck where the perforated metal covering extends all the way across. This provides a smoother aesthetic finish. Two such products are:

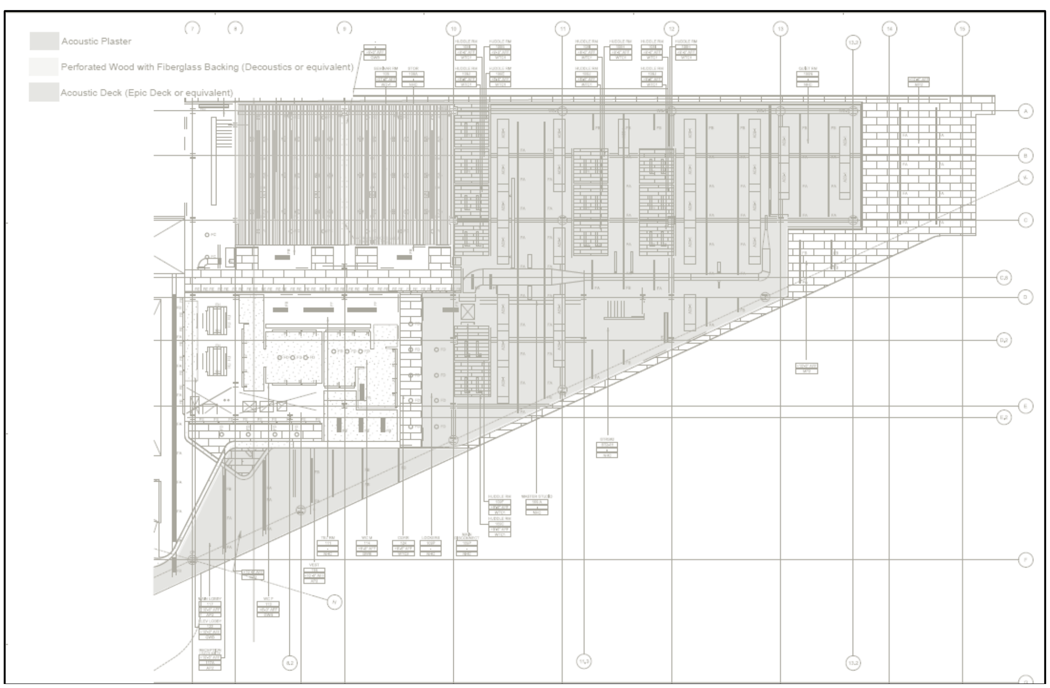
- Canam LFCAS3: http://www.canam-steeljoists.ws/
- Vulcraft 3NPA: http://www.vulcraft.com/

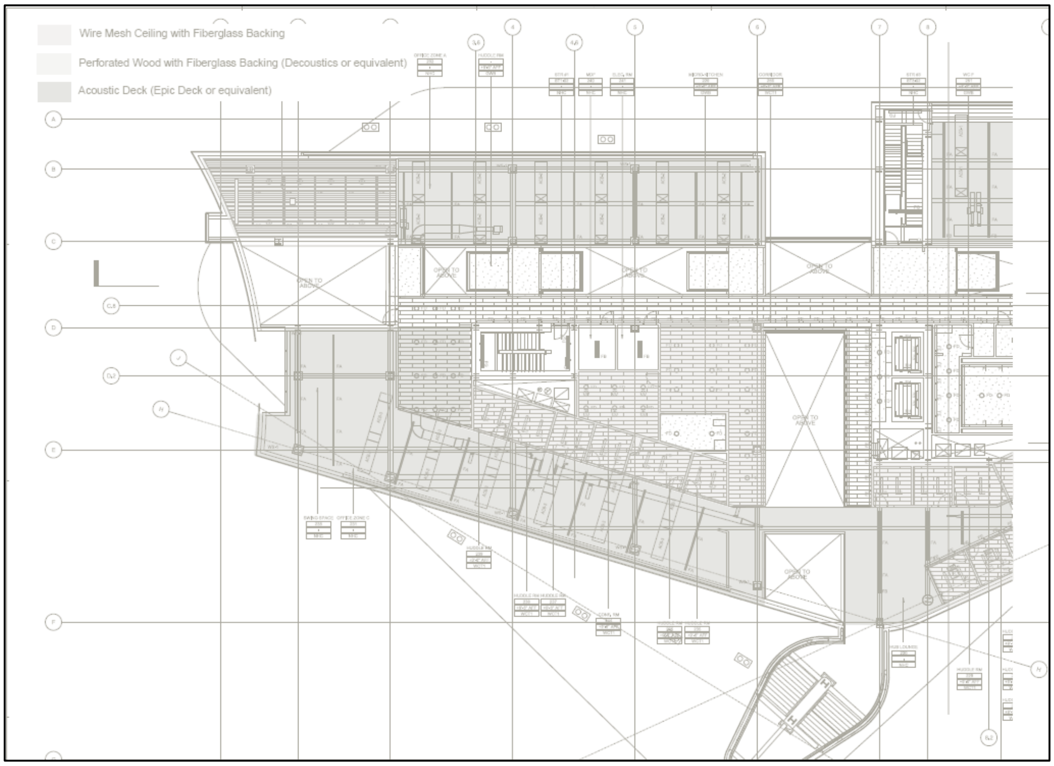
- In huddle rooms and conference spaces with wire mesh ceilings, 1-in thick (minimum) black duct liner should be installed on the underside of the slab in these locations for sound absorption.
- In the ground floor café and lobby areas, sound absorption acoustic plaster on the ceiling is recommended. We recommend the product have a minimum NRC of 0.8 for this product. Fellert can be used as an acoustic basis.
  http://www.fellertna.com/
- In the south conference rooms, sound absorption on the ceiling is also recommended. The current design uses a solid Decoustics panel. We recommend the QPP-19 with E400 Mounting (NRC 0.8).
  http://www.decoustics.ca/products/ceilings/Quadrillo-Panel

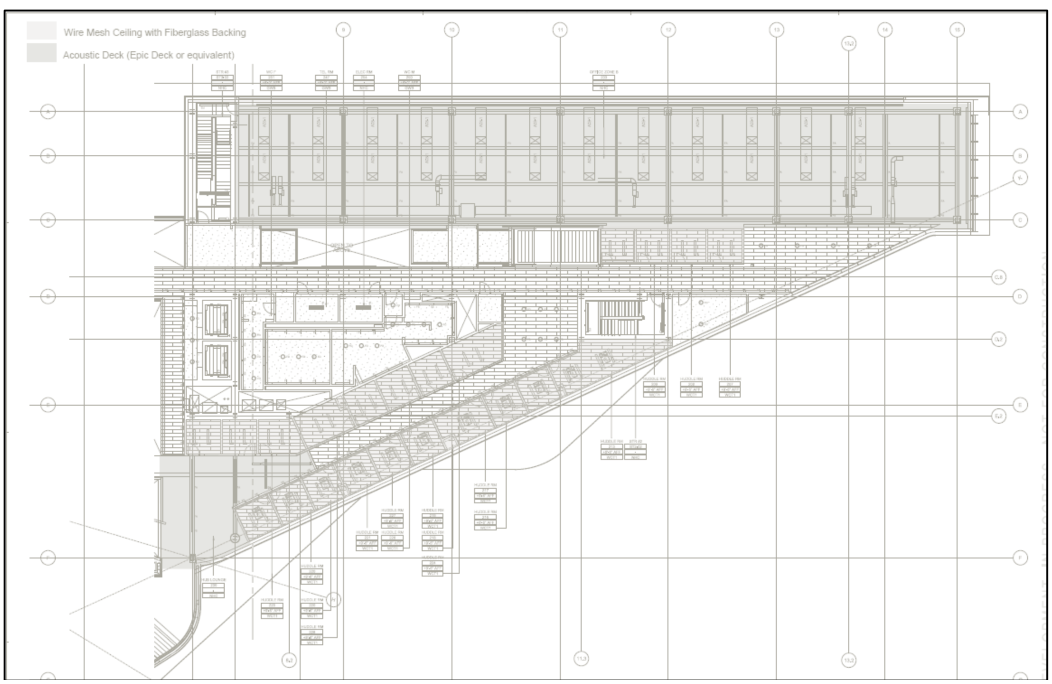
Locations of sound absorbing treatment are shown below:
100% CD Update: all images relate to 50% CD or earlier – recommended locations have been incorporated into 100%CD Architectural Drawings.

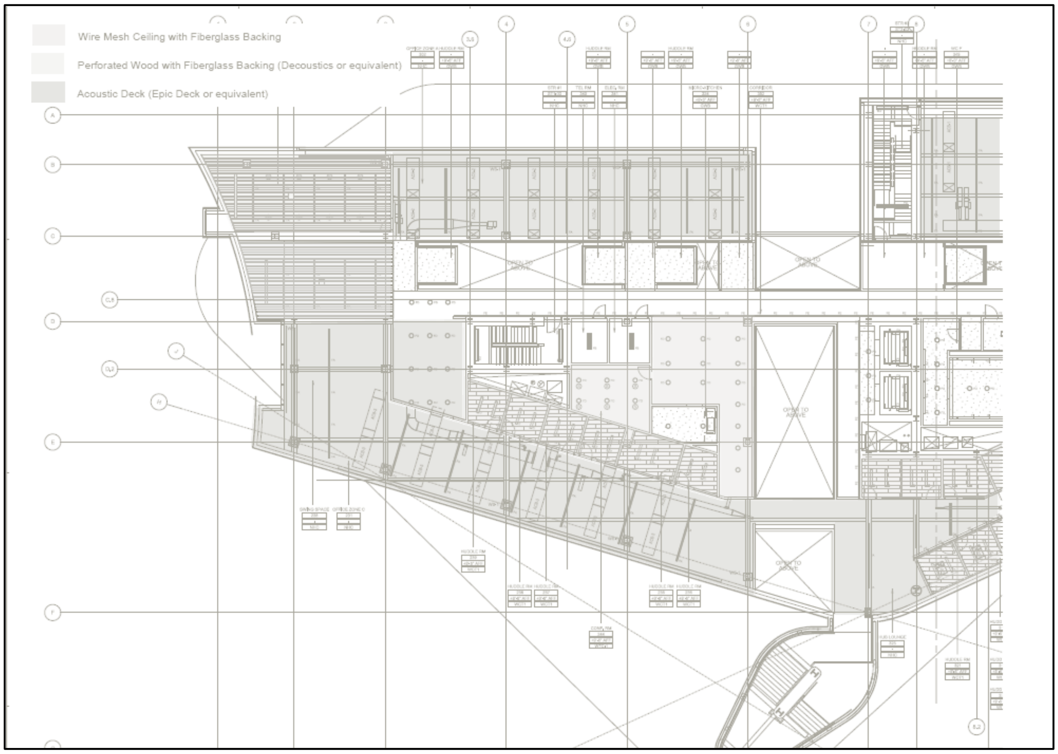

Acoustic Deck (Epic Deck or equivalent)

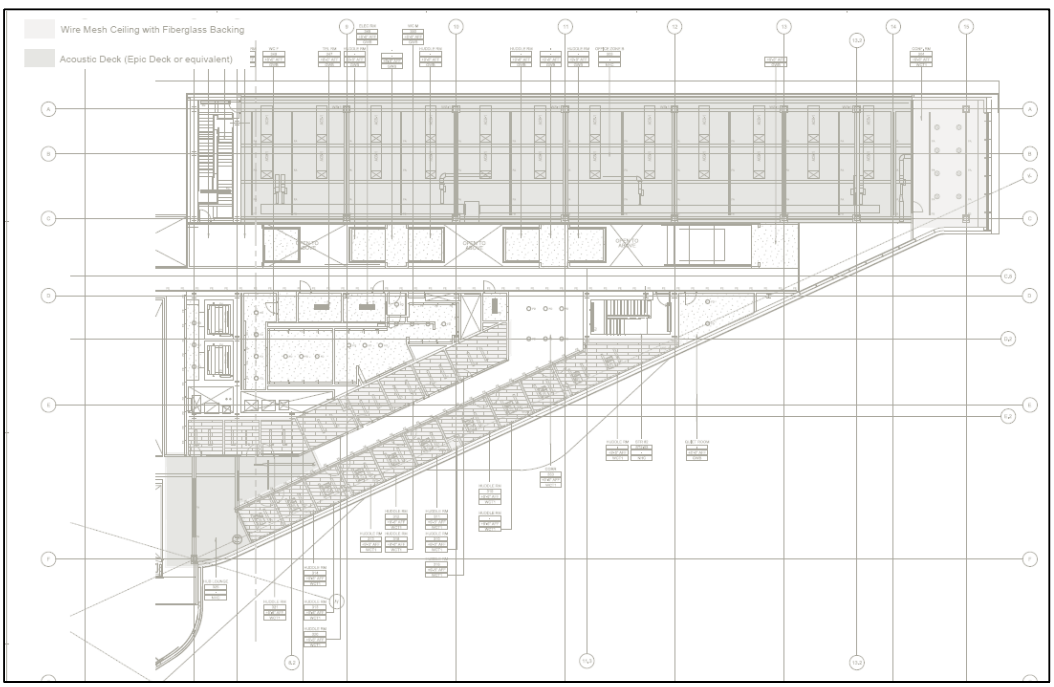

Acoustic Plaster
Chevron Panels with Fiberglass backing (GWB Ceiling above for Sound Isolation)

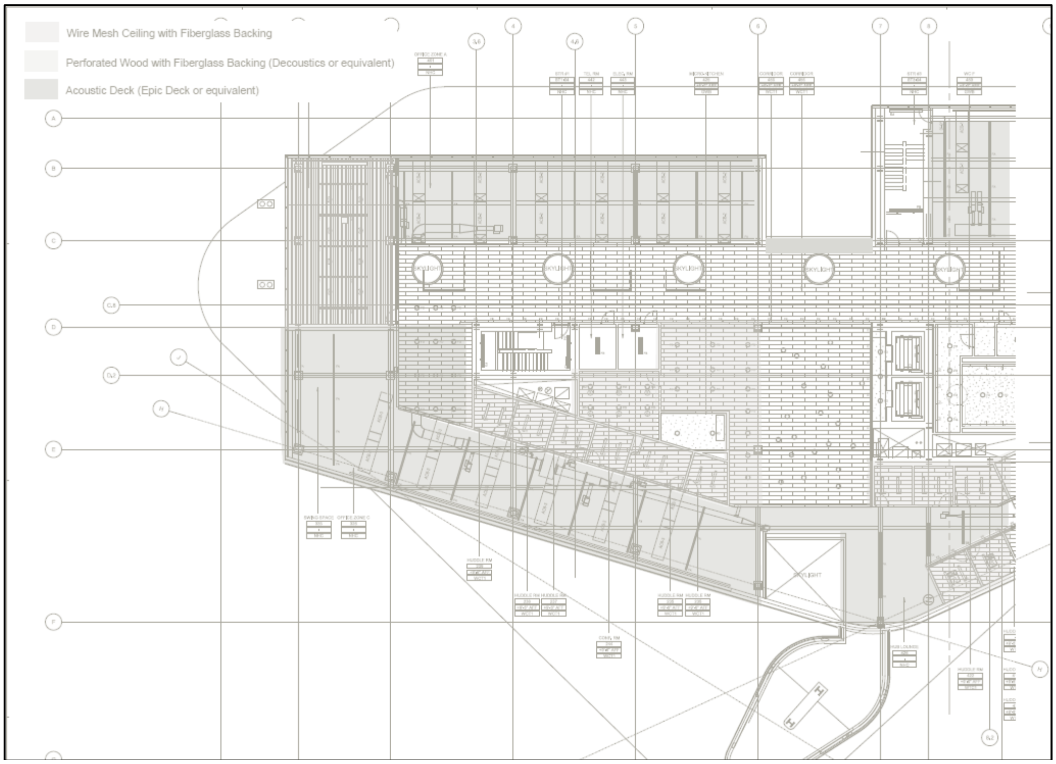

Acoustic Plaster
Perforated Wood with Fiberglass Backing (Decoustics or equivalent)
Acoustic Deck (Epic Deck or equivalent)

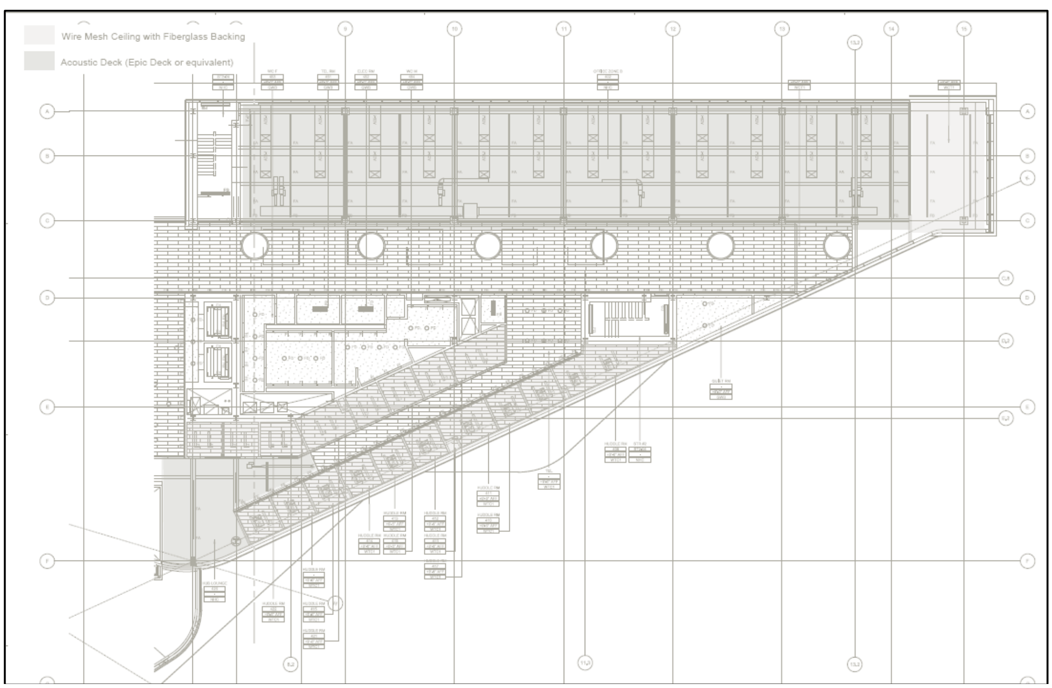

Wire Mesh Ceiling with Fiberglass Backing
Perforated Wood with Fiberglass Backing (Decoustics or equivalent)
Acoustic Deck (Epic Deck or equivalent)


Wire Mesh Ceiling with Fiberglass Backing
Acoustic Deck (Epic Deck or equivalent)


Wire Mesh Ceiling with Fiberglass Backing
Perforated Wood with Fiberglass Backing (Decoustics or equivalent)
Acoustic Deck (Epic Deck or equivalent)


Wire Mesh Ceiling with Fiberglass Backing
Acoustic Deck (Epic Deck or equivalent)


Wire Mesh Ceiling with Fiberglass Backing
Perforated Wood with Fiberglass Backing (Decoustics or equivalent)
Acoustic Deck (Epic Deck or equivalent)


Wire Mesh Ceiling with Fiberglass Backing
Acoustic Deck (Epic Deck or equivalent)

General Vibration Control

The structure should be designed to reduce walking-induced floor vibration as recommended by the AISC Steel Design Guide 11 “Floor Vibrations due to Human Activity”.

Multipurpose Structural Vibration Control

One of the potential uses of the multi-purpose room will be a basketball court. Control of dynamic effects in – and transmission through – the structure due to activities such as basketball would require significant stiffening of the structure and coordination with the structural engineer. Due to the cost and space limitations of this room, the current strategy is that the room will only be used for high-impact activities during non-work hours and therefore the low-frequency transmitted noise and vibration to conference rooms and workspaces will not be deemed disturbing. A traditional sports floor (Action Floors or Mondo - http://www.mondoindoorsportusa.com/) will be used in combination with rubber or fiberglass isolation pads or wire rope isolators to alleviate some of the high-frequency noise transmission. The solutions proposed below are based on cost reduction requirements communicated to Arup by Morphosis and deviate significantly from the scheme design which had higher performance attenuation.

Option 1: Rubber/fiberglass isolation pads spaced 24” o.c. under the sports flooring system. These would have to be attached to the sleepers on the sports floor.

- Regupol RAV-300 Pads (http://www.cmsstructuralisolation.com/products/Regupol%20RAV300.htm)
- Kinetics KIP Pads (http://www.kineticsnoise.com/hvac/kip.html)

Option 2: Custom “circular arch” wire rope isolators. The isolators would be attached to the sleepers under the sports floor An indicative sketch of the wire rope isolators is shown below. Supplier of this type of isolator is Vibration Mountings and Controls (VMC) or Isotech.

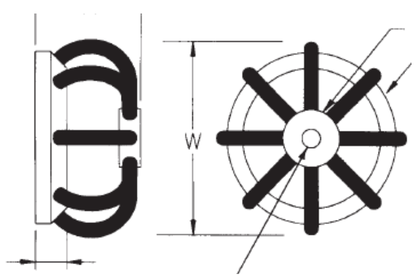


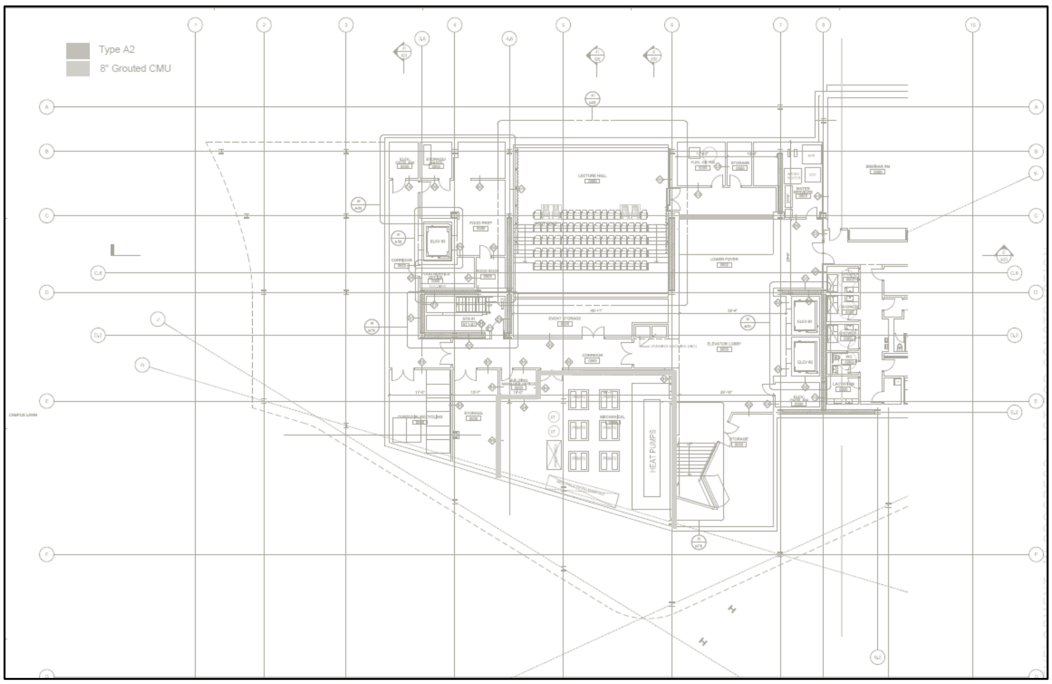
Figure 7

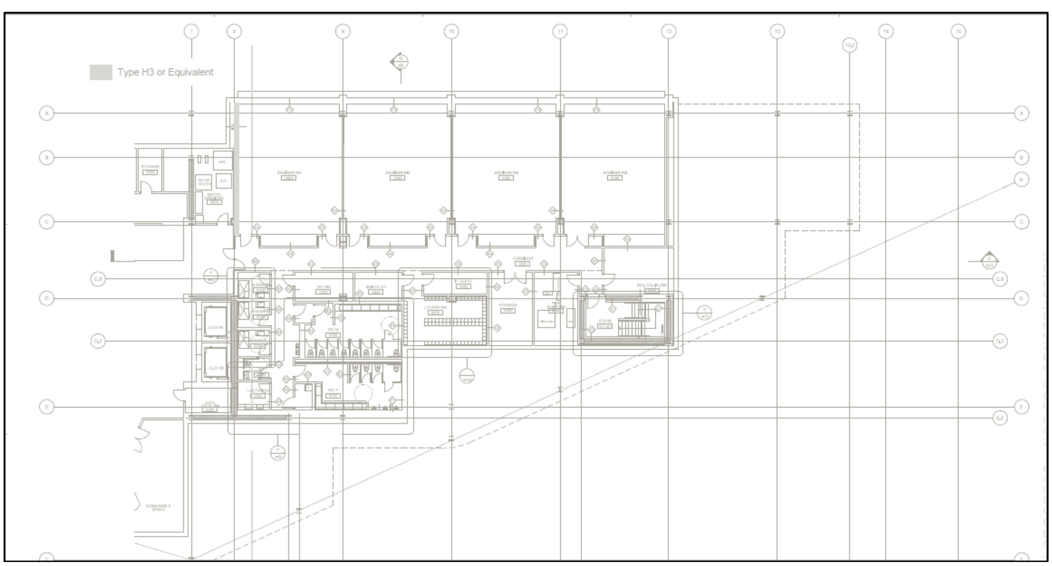
Options 1 and 2 will be studied by Arup and Morphosis in the next phase.

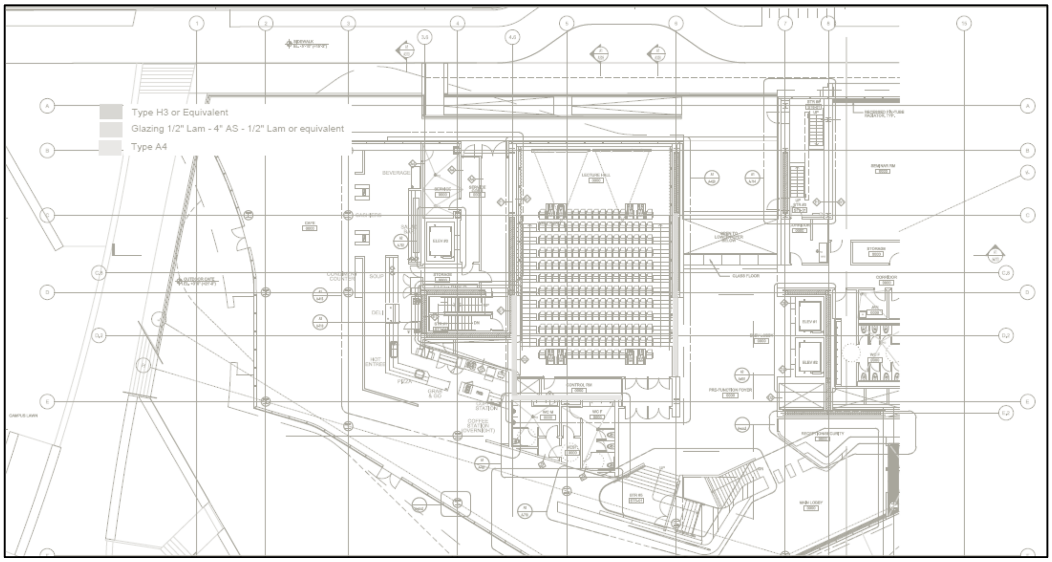
50%CD Update: It is understood that basketball will not be a primary function for the multi-purpose room and that the floor for this room does not need to be designed to mitigate for this activity, as such the isolated floor system is not included in the current design.

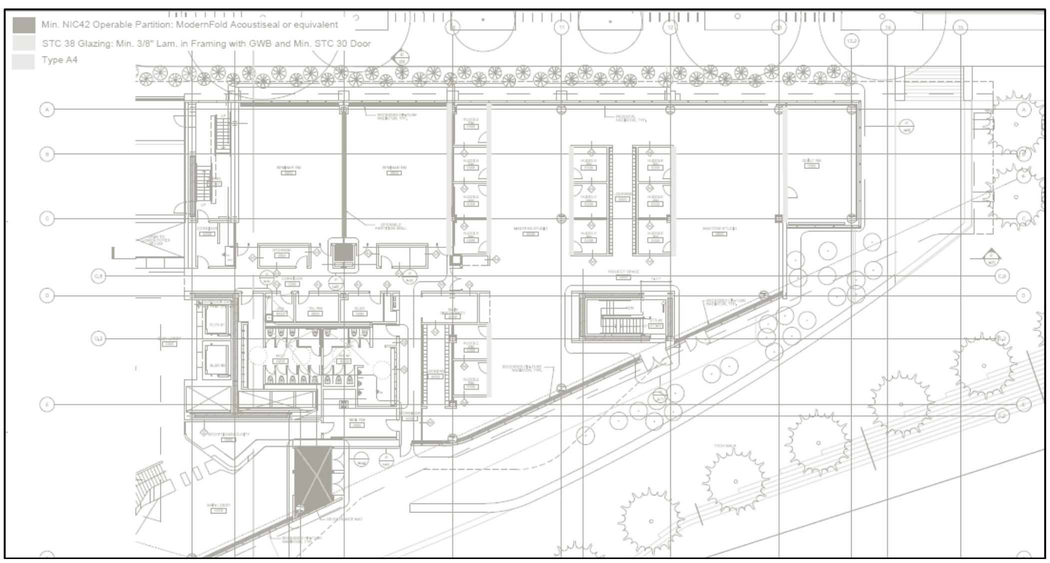
4.9.5 INTERIOR SOUND ISOLATION

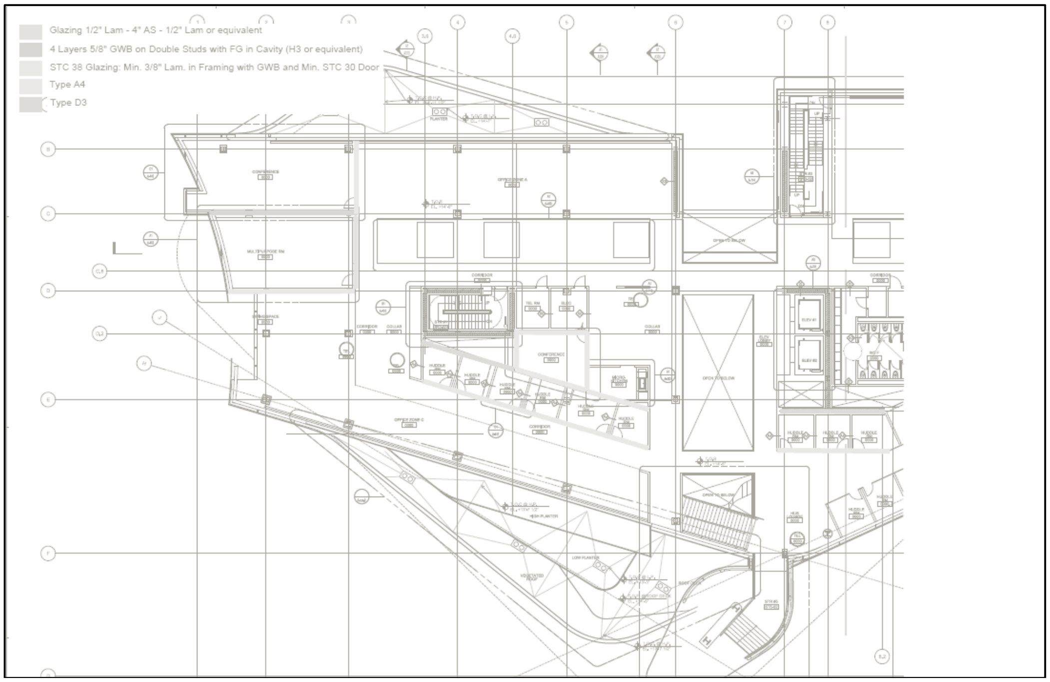
Markups of partitions types and locations are shown below:
50%CD Update: Updates to partition types were outlined in Arup 100%DD acoustic markup dated 11/19/2013.
100% CD Update: all images relate to 50% CD or earlier – recommended locations have been incorporated into 100%CD Architectural Drawings.

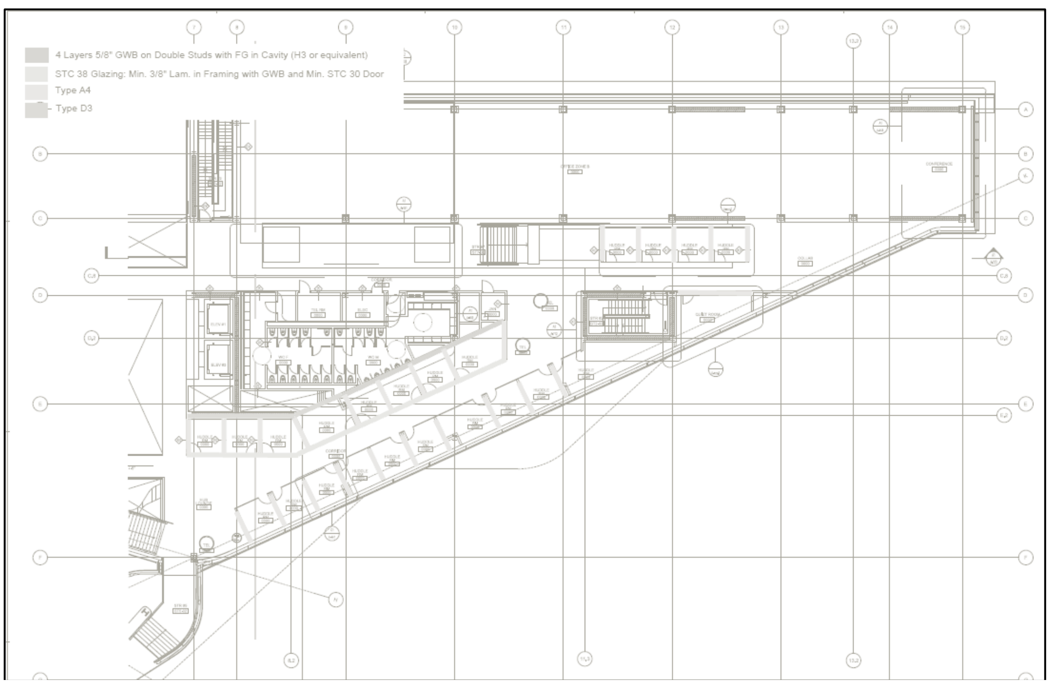


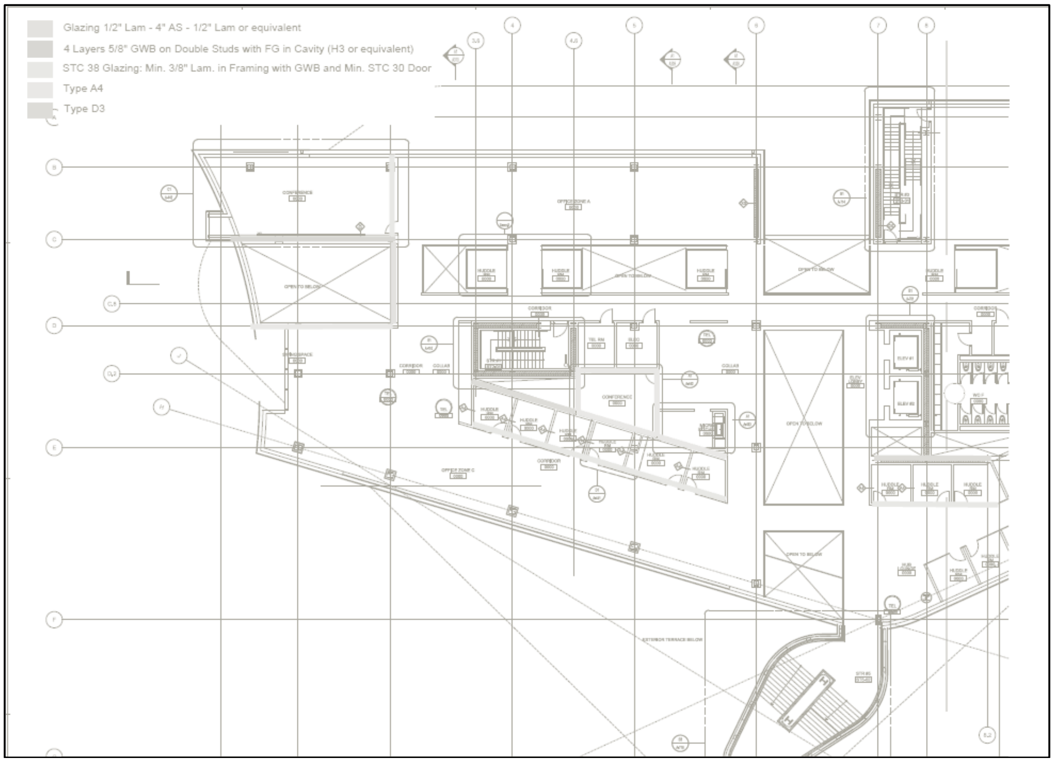


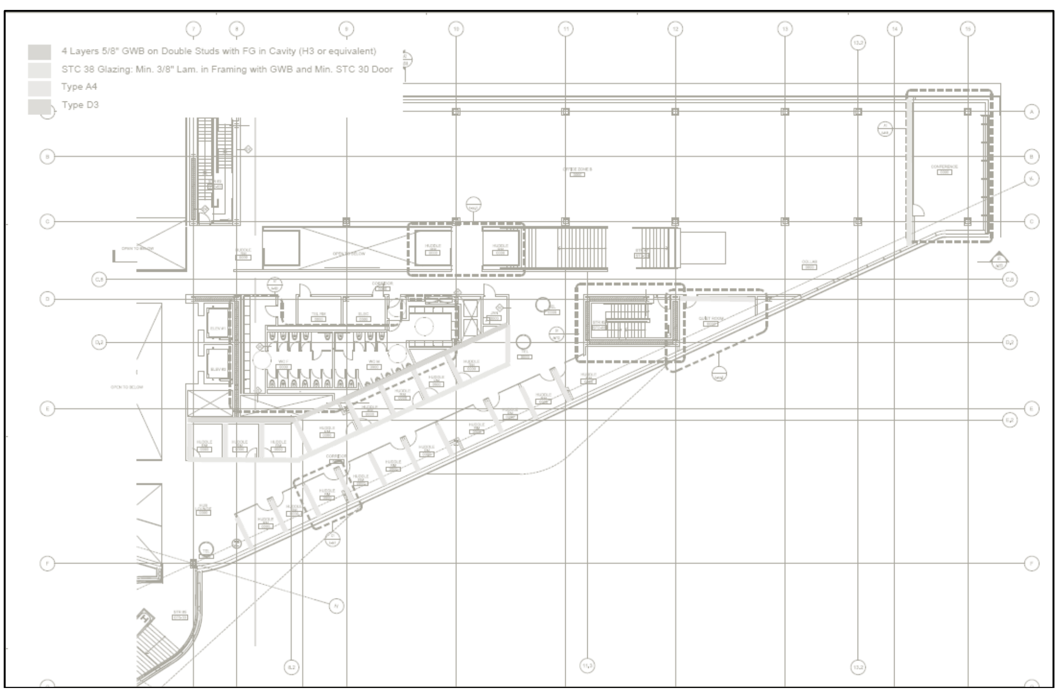

Type H3 or Equivalent
Glazing 1/2" Lam - 4" AS - 1/2" Lam or equivalent
Type A4

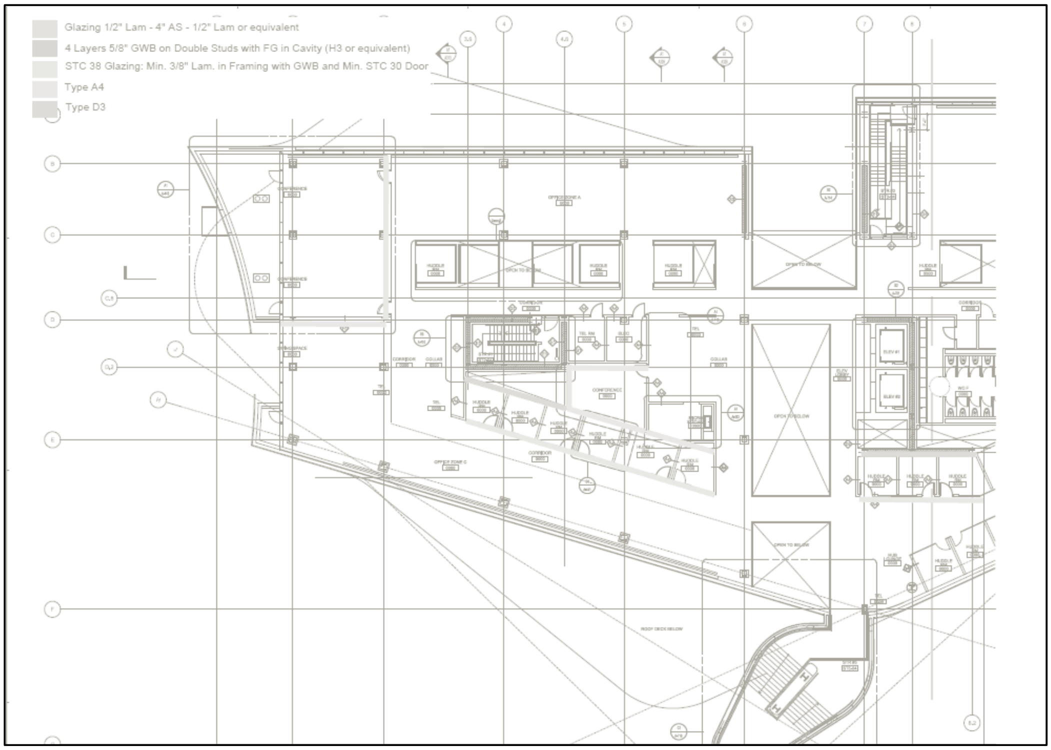

Min. NIC42 Operable Partition: ModernFold Acoustiseal or equivalent
STC 38 Glazing: Min. 3/8" Lam. in Framing with GWB and Min. STC 30 Door
Type A4

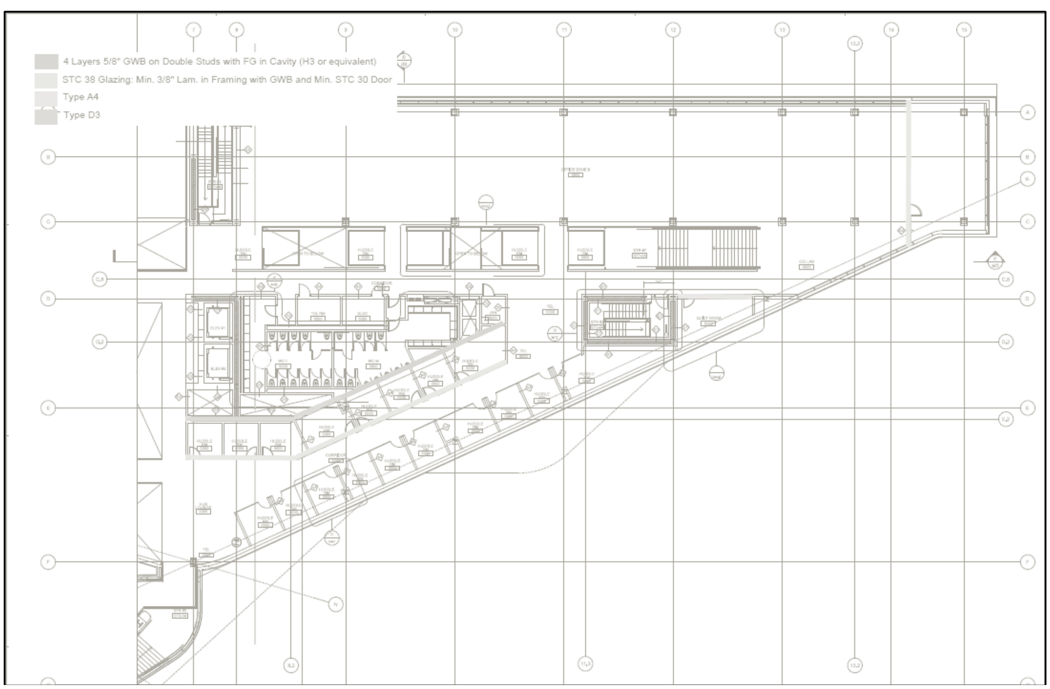

Glazing 1/2" Lam - 4" AS - 1/2" Lam or equivalent
4 Layers 5/8" GWB on Double Studs with FG in Cavity (H3 or equivalent)
STC 38 Glazing: Min. 3/8" Lam. in Framing with GWB and Min. STC 30 Door
Type A4
Type D3


4 Layers 5/8" GWB on Double Studs with FG in Cavity (H3 or equivalent)
STC 38 Glazing: Min. 3/8" Lam. in Framing with GWB and Min. STC 30 Door
Type A4
Type D3


Glazing 1/2" Lam - 4" AS - 1/2" Lam or equivalent
4 Layers 5/8" GWB on Double Studs with FG in Cavity (H3 or equivalent)
STC 38 Glazing: Min. 3/8" Lam. in Framing with GWB and Min. STC 30 Door
Type A4
Type D3


4 Layers 5/8" GWB on Double Studs with FG in Cavity (H3 or equivalent)
STC 38 Glazing: Min. 3/8" Lam. in Framing with GWB and Min. STC 30 Door
Type A4
Type D3

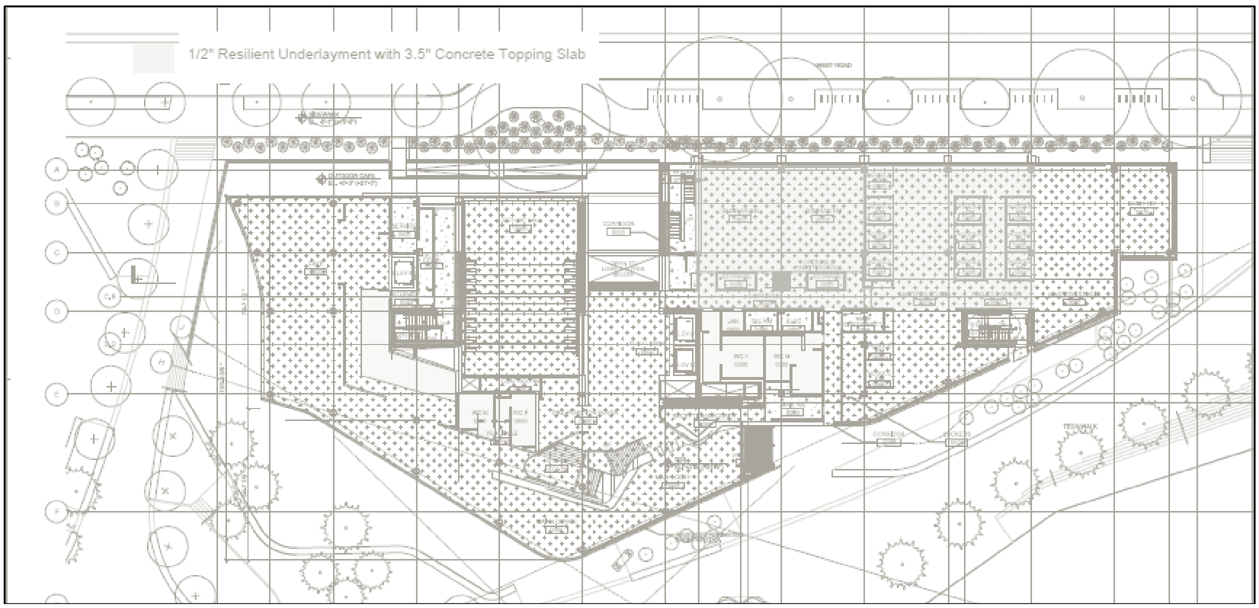


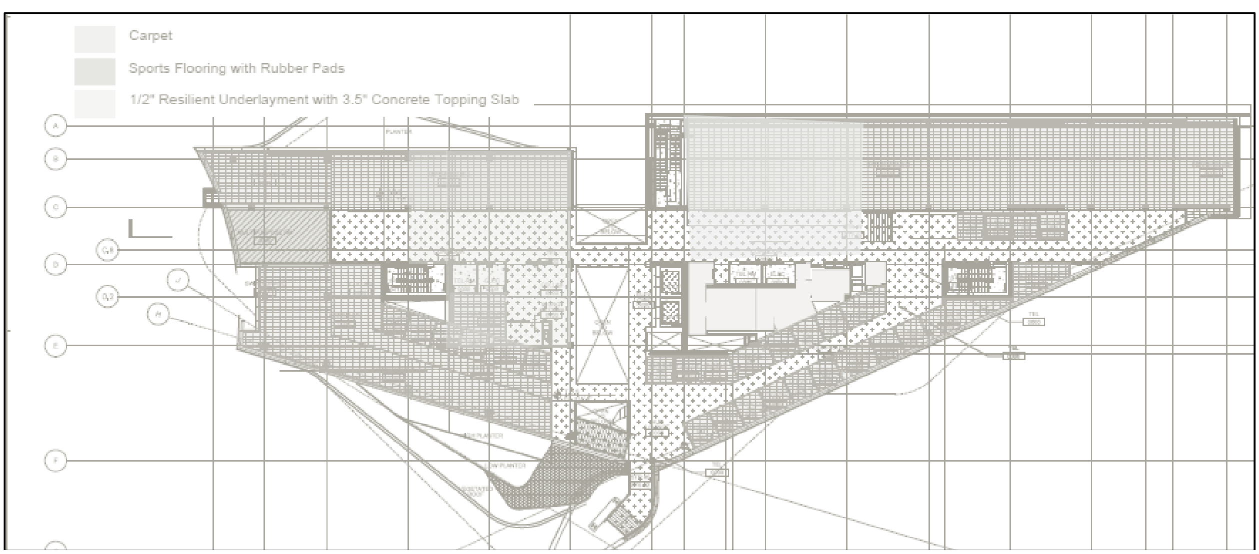


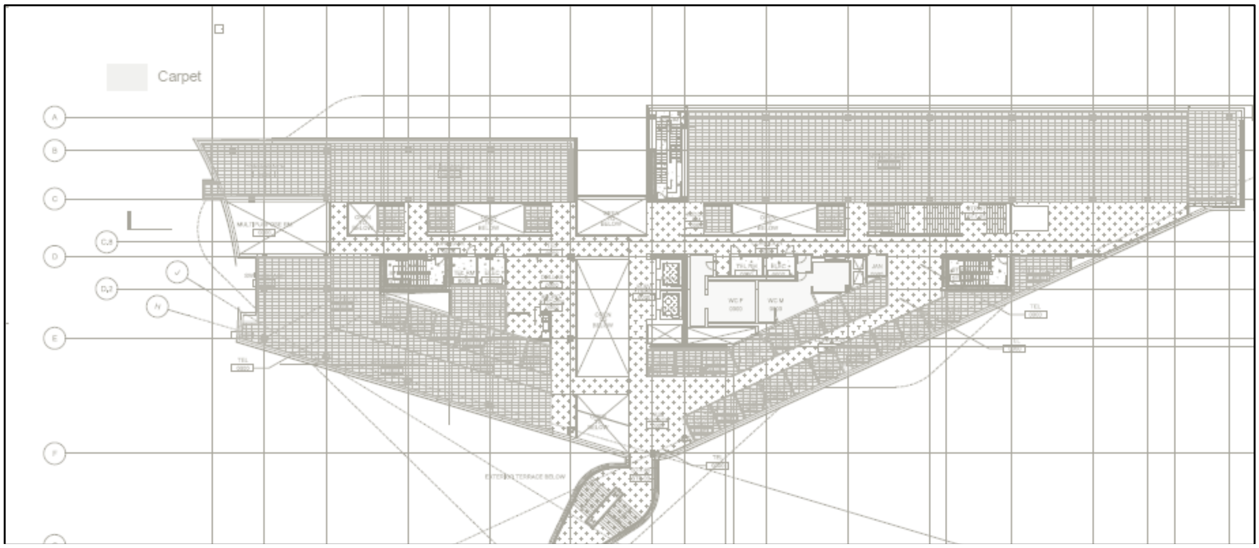
4.9.6 IMPACT SOUND ISOLATION

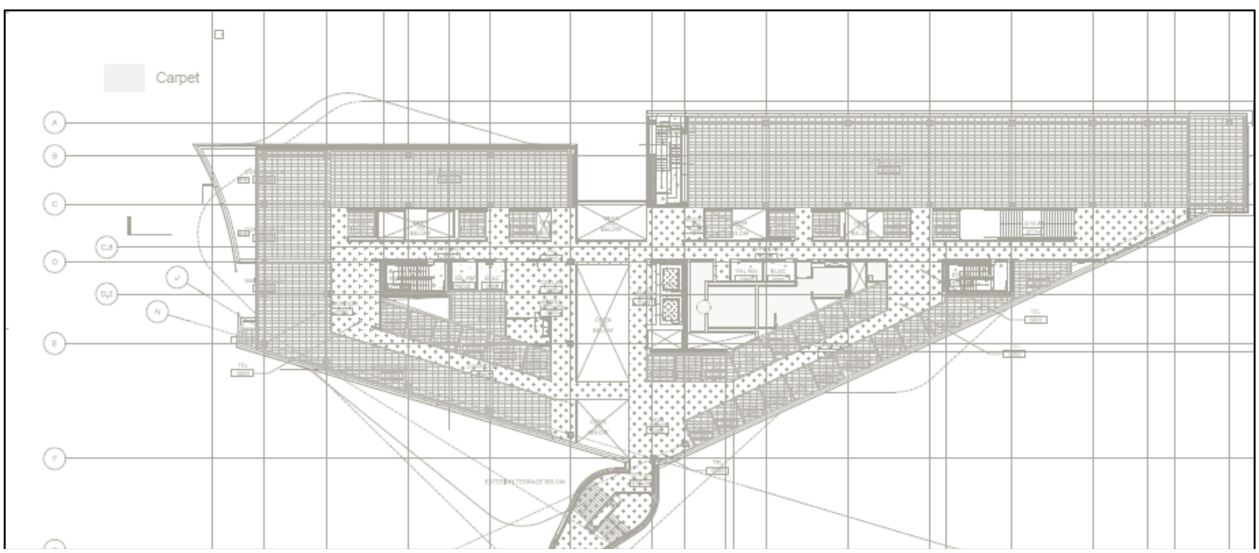
Carpet will be used in many areas to mitigate impact noise. On the ground floor, a smooth concrete finish is preferred. In this area, a resilient underlayment with a concrete topping slab will be used. Above the lecture hall, resilient underlayment is also recommended. Locations and types of impact isolation are shown below:

50%CD Update: The hard floors above the lecture hall and both levels of seminar rooms include a resilient impact layer to help mitigate footfall.
100% CD Update: all images relate to 50% CD or earlier – recommended locations have been incorporated into 100%CD Architectural Drawings.






Carpet


Carpet

4.9.7 GENERAL COMMENTS ON FOLLOWING SECTIONS

The remaining acoustic sections have specific recommendations for individual spaces. The acoustic goals for each space can be partially defined by these metrics:

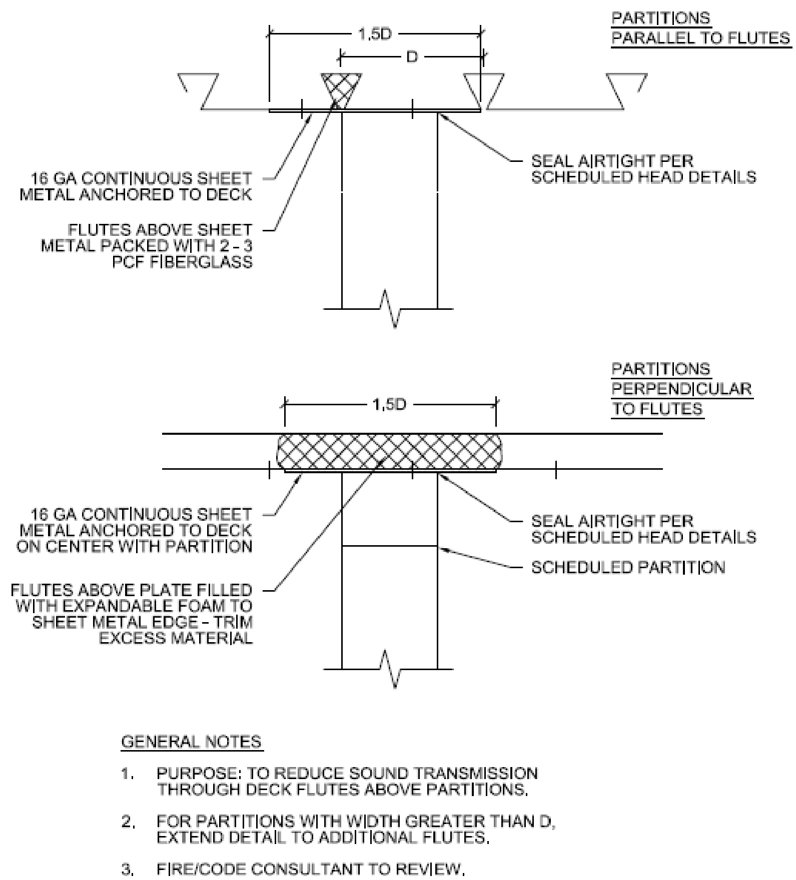
Background Noise: The limits apply to the HVAC system under operating conditions. The limits are provided as a target range. While excessive background noise is not desired, the spaces should not be too quiet, either.

Impact Isolation: This is a performance rating applied to the floor/slab/ceiling *above* the referenced space. A higher number means the acoustic performance is better. Impact noise is controlled via floor finishes or a floor underlayment that provides an increase in “Impact Isolation Class” from the base slab assembly, or ∆IIC. The test standard is ASTME2179. We recommend mock-up testing at an early stage to confirm acoustic performance and a “Robinson Test” to verify that the floor can support loads without cracking.

General Sound Isolation: This refers to the overall airborne sound isolation performance of the constructions surrounding each space. Each component may have a different but similar Sound Transmission Class (STC) rating as the general number. For example, doors are typically 10 points less than the general performance, whereas internal walls are approximately equal to the general rating.

Reverberation Time: This is use to generally define the room acoustic performance and requirements for sound absorbing finishes. Reverberation directly affects speech intelligibility and noise buildup within spaces.

Flanking Sound: Partitions between spaces will require architecture sealing details at the head intersection. Preliminary approach is shown in the following figure.



4.9.8 LECTURE HALL

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 20 - 25	IIC 60 - 65	STC 55 - 60	0.7 to 0.9 seconds

<u>Use</u> The lecture hall acoustics will be designed for speech.

<u>Walls</u> Minimum 4 layers of GWB on double steel studs (Refer to Type H3 in A-005 for detail). Partition should extend full height. See partition review above for locations.

Glazed areas at the rear side walls should be minimum STC50. Basis of design construction is 1/2” Lam - 4” Airspace - 1/2” Lam. Some loud voices will still be audible through this partition.

<u>Doors</u> Current design shows a single set of 1-3/4” insulated steel door with full perimeter seals (STC33) at the front “stage” entrance. The doors open onto the foyer which will have typical circulation and activity noise. As a single doorset, the entrance does not function as a sound/light lock and should

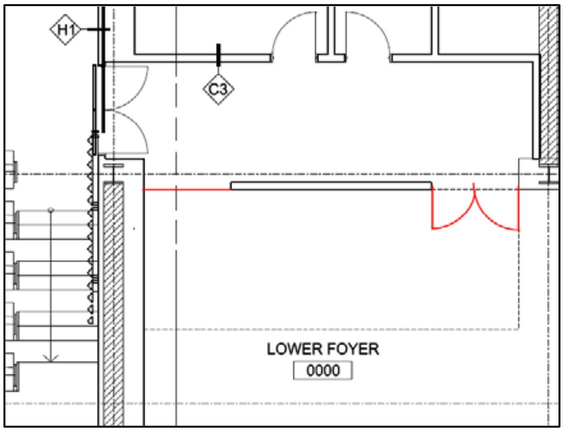
Use

The lecture hall acoustics will be designed for speech.

not normally be openable during lectures to avoid sound/light disturbance.

We recommend one of the following options to improve the performance for sound and light isolation:

A) Add a door from the foyer to create a full sound-light lock. Sound and light from the foyer would be adequately isolated. Example layout shown below:



B) Steel acoustically rated door (min. STC50). The door should be light-tight and air-tight. The door should be supplied with an actuator, ie an electronic pushbar that starts a motor that pushes the door open (the door will be very heavy: 10-12psf). The door should only be openable from inside the room, unless used strictly as an entrance for the disabled per ADA requirements. Frames should be supplied with the door as a total assembly. The door will have to be installed and maintained with considerable care if the acoustic performance is to be sustained in the long term.

C) Alternatively, the design may remain as-is and the door acoustic performance would be similar to Milstein Hall. Milstein has doors that can be heard through and is directly adjacent to corridors. The CNY lecture hall is next to the Foyer and the activity noise may be more frequent.

Morphosis has reviewed and deemed option C acceptable.

The rear entrance doors are sound light lock vestibules. These doors should be solid wood with full perimeter door seals.
100% CD Update: Hollow metal doors and metal door

Use — The lecture hall acoustics will be designed for speech.

frames will be packed with fiberglass insulation to prevent sound transmission and flanking.

Sound-light Locks — The vestibules should have sound absorbing treatment on minimum of 50% of the walls and soffit.

100%CD Update: We understand that the upper level vestibule entrance of the Lecture Hall has been changed to utilize frameless doors. If frameless doors remain, compression seals are recommended on sides and top, and automatic drop seals on the bottom of all doors in the vestibule. Reverse cam-lift hinges may be necessary to allow the door to open and close with a compression seal on top. This is described in more detail in section 4.9.1.

Glass Façade — The front wall has a window looking onto the east river and skyline. There is a road at the façade. Traffic noise transmission through the glass façade should be controlled. The proposed system is: 3/8-in – 1/2-in airspace – 1/2-in lam and an additional inner framed movable wall system comprised of 1/2-in laminated glass spaced minimum of 8 inches from the outer glass.

The system should seal airtight between the outer glass and the inner room. This to adequately attenuate low frequency noise from trucks. Other window buildups may be suitable with varying levels of acoustic performance (e.g. if some noise ingress is acceptable).

50%CD Update: The external inner glazing does not extend full height, providing no benefit for controlling external noise ingress. As a result it is predicted that low frequency noise from external traffic activity will be audible within the lecture hall, levels are predicted to be comparable to Millstein Hall.

Impact Isolation — *Above* the auditorium, a resilient underlayment will be installed between the slab and a 3.5-inch topping slab. This resilient layer should provide an ΔIIC20. Recommended products are:

- Maxxon Enkasonic (½") (http://www.maxxon.com/enkasonic/data)
- Regupol ProCurve 17 (¾") (http://www.rubberunderlayments.com/impacta-regupol-procurve.htm)

Finishes — In SD, we recommended that the lecture hall should include approximately 2400ft^2 of sound absorbing finishes with a nominal acoustic rating of NRC 0.80.

<u>Use</u>

The lecture hall acoustics will be designed for speech.

Current design applies a chevron pattern to the walls and ceiling that approximates a slat absorber. This material is separated by air gaps in a 5:1 width ratio, with space behind to allow airflow in and out of the gaps. Given a large airspace and sound absorbing treatment behind, the performance of this pattern can be utilized to provide appropriate acoustics in the space. There will be sound absorption behind the chevron panels on the walls and ceilings. The exact locations and quantities will be determined in the next phase. We anticipate 70% of the surfaces behind the chevrons to be treated with 2 inch thick black ductliner or fiberglass.

100%CD Update:
The basis product for the chevrons is Oberflex Obersound Micro with solid MDF substrate and no fiberglass in cavity (sound reflecting). 2 inch thick fiberglass will be mounted behind the baffles evenly distributed on 90% of the side walls (1600 ft^2) and ceiling (2200 ft^2) with a 2 inch air space between baffles and fiberglass. The fiberglass will have a perforated metal facing, with minimum 20% open area (basis McNichols 20 ga. 3/32” round perforations staggered on 3/16” centers).

The basis product for treatment on available rear wall surfaces is Oberflex Obersound Micro with 16mm perforated MDF substrate, 2 inch fiberglass on 8 inch airspace. The total surface area of acoustic treatment on the rear wall is 175 ft^2.

Oberflex Obersound products can be found here: http://www.oberflex.com/388-acousitc-solution-obersound-micro-perforated-collection.html#the-product

<u>HVAC Design</u>

To achieve the recommended background noise targets, air velocities within the room will need to be very low.

Currently air will be supplied via an evenly distributed grid of diffusers in the ceiling. Air will return through a single duct in the ceiling plenum. Ducts in the ceiling will need to be large with lining and potential lagging to prevent breakout noise into the room below.

<u>Control Room</u>

We recommend an enclosed control booth. An enclosed control room would allow the following:

- Operator(s) would be able to multi-task, i.e. set-up and leave the equipment unattended, coming back occasionally to check. AV staff would be able to solve

Use The lecture hall acoustics will be designed for speech.

other problems in the building without disrupting the class in the lecture hall. They would also be able to have low level conversations.

- The projectors will need to be in an enclosed room to control their noise. They should be located in the control room.
- The room would have an operable window so they can hear the hall from within the control room and communicate to people at the front of the space. The basis glazing is a single glazed ½ inch pane.
- The AV equipment to be in a lockable room.

50%CD Update: The control room window will be fixed and should be angled to accommodate projection.
100% CD Update: The control room window will be operable (basis St. Cloud 940 Horizontal Roller, STC 42) and angled up at a minimum 7 degree angle.

4.9.9 SEMINAR ROOMS

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 30 - 35	IIC 50 - 55	STC 50 - 55	0.5 to 0.7 seconds

Use The seminar room acoustics will be designed for speech.

Walls Minimum 4 layers of GWB on single steel stud (Refer to Type A4 in A-005 for detail). Partition should extend full height. See partition review above for locations.

Operable Partitions L1 Seminar rooms are separated by an operable partition. We recommend a minimum NIC42 partition such as ModernFold Acoustiseal or equivalent:
http://www.modernfold.com/operable_partitions_paired_panel.aspx

Panels should be guaranteed with 2 previous field test reports. Lab ratings alone are not sufficient for acceptance testing.

100% CD Update: Additional operable partition has been designed for 2 of the L0 Seminar rooms. Recessed jamb seals have been recommended for both sides of the partition (inside pocket and at column), with stud behind to prevent flanking between adjacent rooms.

Water Services L0 Seminar rooms are adjacent to Water Services room. Minimum 4 layers of GWB on double steel studs (Refer to Type H3 in A-005

Adjacency	for detail). Partition should extend full height. See partition review above for locations. We anticipate small in-line booster pumps and fire pump equipment (fire equipment used only in emergency or infrequently).
Doors	The entrance doors should be insulated hollow metal with full perimeter door seals. **100% CD Update: Honeycomb metal doors will be used and metal door frames will be packed with fiberglass insulation to prevent flanking.**
Glass Façade	3/8-in – 1/2-in airspace – 1/4-in. Airtight vertical mullions. Mullions at wall intersections in the seminar rooms will require a coverplate design. Basis for coverplate is “Mull-it-over”. Coverplate design can also be part of the curtainwall scope. See façade acoustic section. **100% CD Update: Refer to section 4.9.3 for updates.**
Impact Isolation	Current design for the ground floor Seminar Rooms (and the adjacent Workspaces) is polished concrete finish on the floor. A resilient underlayment should be installed between the finish floor and the structural slab on upper floors in order to mitigate impact noise transmission to the L0 Seminar Rooms. This resilient layer should provide ΔIIC20 per ASTM2179. Recommended products are: - Maxxon Enkasonic (½”) (http://www.maxxon.com/enkasonic/data) - Regupol ProCurve 17 (1/2”) (http://www.rubberunderlayments.com/impacta-regupol-procurve.htm) Workspaces above the L1 Seminar rooms will have carpet on the floor for impact isolation.
Finishes	Current design shows the sound absorbing deck (basis of design Epic Metals Epicore 3.5A, minimum NRC 0.80) in the L0 seminar rooms. Current design shows the ceilings of the ground floor seminar rooms as Perforated panels with fiberglass backing (Decoustics Quadrillo or equivalent, NRC 0.8) hung from the structural deck. In addition, we recommend a minimum of 2 adjacent walls with tackable sound absorbing panels. Basis: 1 inch fabric wrapped fiberglass (NRC0.80) from 3-ft A.F.F. to door height.

<u>HVAC Design</u>

The system will be supplied by a VAV system. VAV boxes should be located outside of the room.

Supply air paths should be ducted fully ducted to the room from the AHU.

Return air paths from L0 seminar rooms can have transfer ducts to a corridor plenum if duct is minimum 10 feet in length and lined with 2" duct liner and includes 2 elbows.

Return air paths from L1 seminar rooms can have transfer ducts to a corridor plenum if duct is minimum 30-inches in length and lined with 2" duct liner and includes 2 elbows. Additionally the ceiling plenum in the L1 seminar rooms should be lined with 1" fiberglass or equivalent. Transfer ducts should NOT be used between adjacent seminar rooms.

4.9.10 MASTERS STUDIO

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 35 - 40	IIC 45 - 50	N/A	0.5 to 0.7 seconds

<u>Use</u>

The studio will be an open flexible workspace and will require reverberant noise control and consideration of background noise for privacy and comfort.

<u>Impact Isolation</u>

Portions of the masters studio is above seminar rooms and the studio flooring on upper slabs should include an impact insulation floor underlayment that achieves a minimum ∆IIC19 per ASTM2179. The floor is a smooth concrete topping slab with resilient underlayment above the structural slab. This resilient layer should provide ΔIIC20 per ASTM2179. Recommended products are:

- Maxxon Enkasonic (½") (http://www.maxxon.com/enkasonic/data)
- Regupol ProCurve 17 (¾") (http://www.rubberunderlayments.com/impacta-regupol-procurve.htm)

The spaces *above* the masters studio (i.e. office zones, huddle rooms, corridors, and library) will have carpet on the floor for impact isolation.

<u>Finishes</u>

Current design shows sound absorbing deck (basis of design Epic Metals Epicore 3.5A, minimum NRC 0.80) in these areas.

<u>HVAC Design</u>

The HVAC design is a chilled beam system. This type of

HVAC system is expected to be quieter than the recommended range.

4.9.11 PROJECT SPACE

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 30 - 35	IIC 45 - 50	N/A	0.5 to 0.7 seconds

Use — This will be a flexible workspace and will require reverberant noise control. We also anticipate that students may present their work in the space and speech must be intelligible for presentation with un-amplified acoustics.

Finishes — Current design shows sound absorbing deck (basis of design Epic Metals Epicore 3.5A, minimum NRC 0.80) in these areas.

HVAC Design — The HVAC design is a chilled beam system. This type of HVAC system is expected to be acceptable for the space in regards to noise.

4.9.12 MAIN LOBBY, FOYER, ELEVATOR LOBBY, LOUNGE, GALLERIA

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 30 - 45	N/A	N/A	1.2 to 1.8 seconds

Use — The main lobby, pre-function and lounge will require reverberant noise control. The spaces may accommodate events however the spaces are not specifically designed for speech intelligibility or music.

100% CD Update: Full-height glazing will separate the galeria and main atrium shafts from the open office and collaboration areas at levels L1-L3 to control noise levels in these areas. L4 atrium shafts will also be fully glazed to prevent higher atrium noise levels from being clearly audible in open office areas.

Impact Isolation — These spaces are slab-on-grade and do not require impact isolation underlayment.

Finishes — The ceiling should be 100 percent covered with an acoustic plaster with minimum NRC of 0.80. Basis of design is Fellert.

HVAC Design — The HVAC design is a VAV system. This type of HVAC system is expected to be acceptable for the spaces in regards to noise.

Skylight Rain Noise — **50%CD Update:** Rain noise on the Galleria skylights is expected to be audible but given the thickness of glazing is not predicted to disturb normal-level conversation.

4.9.13 CAFÉ, MEZANNINE AND SERVING AREA

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 35 - 40	45 – 50*	N/A	1.2 to 1.8 seconds

Use — These spaces are used for dining and will require reverberant noise control. The spaces may accommodate events however the spaces are not specifically designed for speech intelligibility or music.

Impact Isolation — While these spaces are not directly above the lecture hall, impact noise from the café and serving areas can transmit horizontally through the floor slab to the hall. The inner gypsum wall of the auditorium can be decoupled from the structure to reduce sound transmission.

Finishes — The ceiling should be 100 percent covered with an acoustic plaster with minimum NRC of 0.80. Basis of design is Fellert

HVAC Design — The HVAC design is VAV system. This type of HVAC system is expected to be acceptable for the spaces in regards to noise.

4.9.14 OFFICE ZONES

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 35 - 40	45 - 50	N/A	0.5 to 0.7 seconds

Use — The office zones will be open workspaces and will require reverberant noise control and adequate levels of background noise for privacy and comfort.

Ability to perform and deliver work is strongly influenced by human interaction, communication and sound. While communication and interaction will be required in some spaces, it is recommended that there are designated quiet areas within the office zones where individuals can work without distraction. These areas should have architectural barriers to shield noise from typical open-plan workspace.

In open-plan work areas, the strategy for maintaining a balance between communication, comfort and distraction could be with the following approach:

- Reverberant noise control via sound absorbing ceilings to reduce transmission of conversations throughout the workspace.
- Workstations or dedicated areas with partial dividers. Line-of sight division, when coupled with sound absorbing ceilings can provide a modest amount of separation.

Glass Façade: Steady traffic noise will be heard through the glass façade in most office zone areas. The noise will mix with the HVAC and sound masking system background noise and has a beneficial impact on the acoustics of the space. Some sound masking is needed to provide a moderate amount of workspace privacy.

Impact Isolation: Current design shows carpet on the floor in all Office areas in order to mitigate impact noise transmission to spaces below and prevent footfall noise in the space from being distracting.

Finishes: Epic Metals Epicore 3.5A (minimum NRC 0.80) as basis of design for sound absorbing soffit.

HVAC Design: The HVAC design is a chilled beam system. This type of HVAC system is expected to be quieter than the recommended range.

4.9.15 MULTI-PURPOSE ROOM

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 35 - 40	45 - 50	Special*	0.7 to 1.0 seconds

Use: The space is a multipurpose “games room” with flexible usage. One of the anticipated uses is basketball. Noise from sports and game activities will be controlled but not fully contained within the space.

Sound Isolation: The multipurpose room, if used as a basketball court, will have high levels of airborne and impact sound. Currently, due to cost and space restrictions, the isolation scheme recommended in SD will not be considered. Instead, the basketball and other high-impact functions will be restricted to “after-hours” use to prevent disturbance to adjacent conference rooms and office areas.

Partitions to adjacent conference room should be minimum 4 layers of GWB on double steel studs (Refer to Type H3 in A-005 for detail). Partitions to adjacent office area should be minimum 4 layers of GWB on single steel stud (Refer to Type A4 in A-005 for detail). Partitions should extend full height. See partition review above for locations.

Glazed partition to the corridor/office area should be minimum STC50. Basis of design construction is
1/2” Lam - 4” Airspace - 1/2” Lam.

Doors

The entrance doors should be insulated hollow metal with full perimeter door seals. The door should face the swing space area with is less sensitive than the office desks.

100% CD Update: Hollow metal doors and metal door frames will be packed with fiberglass insulation to prevent sound transmission and flanking.

Floor Design

Refer to structural acoustics section above. Current design includes a traditional sports flooring on sleepers top of wire rope or rubber isolators above the structural slab. Exact details will be worked out in the next phase.

100% CD Update: It is understood that basketball will not be a primary function for the multi-purpose room and that the floor for this room does not need to be designed to mitigate for this activity, as such the isolated floor system is not included in the current design.

HVAC Design

All air should be ducted into the space.

4.9.16 SWING SPACES, COLLABORATION SPACES AND HUB LOUNGES

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 35 - 40	45 - 50	N/A	N/A

Use

These spaces will be used for informal meetings and as general gathering spaces. Reverberation criteria have been relaxed since SD to reduce costs. The spaces were not deemed as critical meeting spaces.

Finishes

In critical collaboration areas (adjacent to small conference rooms) on L2-4 the ceiling will be wire mesh ceiling with fiberglass backing for sound absorbing purposes.

All other spaces will have untreated exposed deck on the ceiling and concrete on the floor. These spaces will be lively and noise levels may build up in these areas.

HVAC Design — The HVAC design is a chilled beam system. This type of HVAC system is expected to be quieter than the recommended range.

4.9.17 PANTRIES

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 40 - 45	45 - 50	N/A	N/A

Use — Space will be used for Food self-service. People will gather, converse, eat and drink. Reverberation criteria have been relaxed since SD to reduce costs. The spaces were not deemed as acoustically critical spaces.

Finishes — Microkitchens are currently shown with concrete floors and gypsum ceilings. These spaces will be lively and noise levels may build up in these areas.

Equipment Noise — The equipment should be selected by the owner with consideration to noise. Transient sounds such as ice machine compressors should be controlled at the equipment selection stage.

4.9.18 CONFERENCE ROOMS

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 25 - 30	55 - 60	STC 50 - 55	0.5 to 0.7 seconds

Use — The spaces will be used for formal meetings and video conferences.

Walls — Partitions to adjacent Multipurpose room should be minimum 4 layers of GWB on double steel studs (Refer to Type H3 in A-005 for detail).

Glazed partition to the corridor/office area should be minimum STC38. Basis of design is the Altos system by Teknion partition systems. **50%CD Update:** Design has ½” tempered glass which is predicted to provide STC 35 to 37.

All other conference room partitions to should be minimum 4 layers of GWB on single steel stud (Refer to Type A4 in A-

005 for detail).

Doors	The entrance doors should be insulated hollow metal with full perimeter door seals. **100% CD Update: Honeycomb metal doors will be used and metal door frames will be packed with fiberglass insulation to prevent flanking.**
Glass Façade	Refer to façade acoustics section. There are different requirements for conference rooms at the north and south of the building.
Impact Isolation	Spaces *above* conference rooms (including other conference rooms) will be carpeted to mitigate transmission of impact noise.
Finishes	Current design shows the ceilings of the Large conference rooms as Perforated panels with fiberglass backing (Decoustics Quadrillo or equivalent, NRC 0.80) hung from the structural deck. Current design shows the ceilings of the Small conference rooms as wire mesh ceiling with fiberglass backing for sound absorbing purposes. We recommend minimum of 2 adjacent walls with tackable sound absorbing panels. Basis: 1 inch fabric wrapped fiberglass (NRC0.80) from 3 feet A.F.F. to door height. Coordination of this requirement and the writing surfaces will be developed between Morphosis and Arup in the next stage.
HVAC Design	The system will be supplied by a VAV system. VAV boxes should be located outside of the room. Supply air paths should be ducted fully ducted to the room from the AHU. Return air paths can have transfer ducts to a corridor plenum if duct is minimum 30-inches in length and lined with 2” duct liner and includes 2 elbows. Additionally the ceiling plenum in the conference rooms should be lined with 1” fiberglass or equivalent. Transfer ducts should NOT be used between adjacent conference rooms.

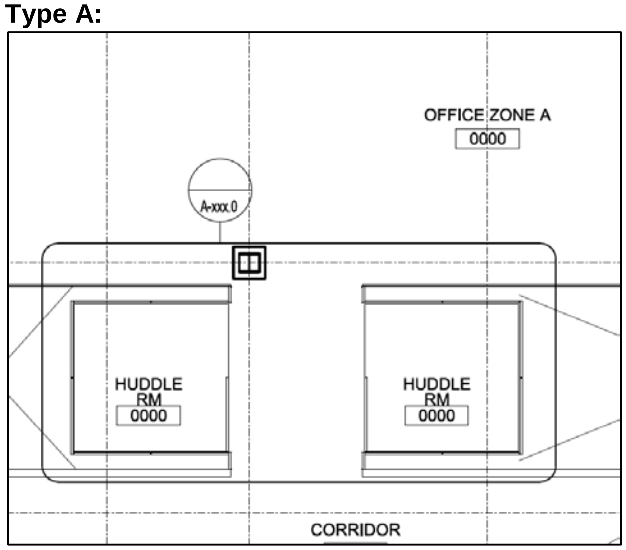
4.9.19 HUDDLE ROOMS

Type	Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
A	NC 40 - 45	NA (open)	NA (open)	0.3 to 0.5 seconds
B	NC 30 - 35	45 - 50	NA (open)	0.3 to 0.5 seconds
C	NC 30 - 35	45 - 50	STC 45-50 between rooms STC 30 – 35 at front walls	0.3 to 0.5 seconds

<u>Use</u>

Huddle rooms will be divided into three types based on their level of acoustic privacy.

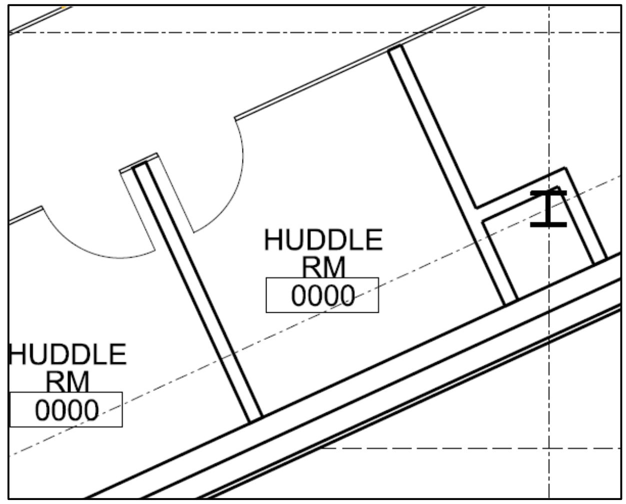
Type A:



These rooms are intended to be visually open, and privacy is not critical. Current design shows open ceiling and glazed walls with openings (no door) for entry.

All-glass huddle rooms are Type A.

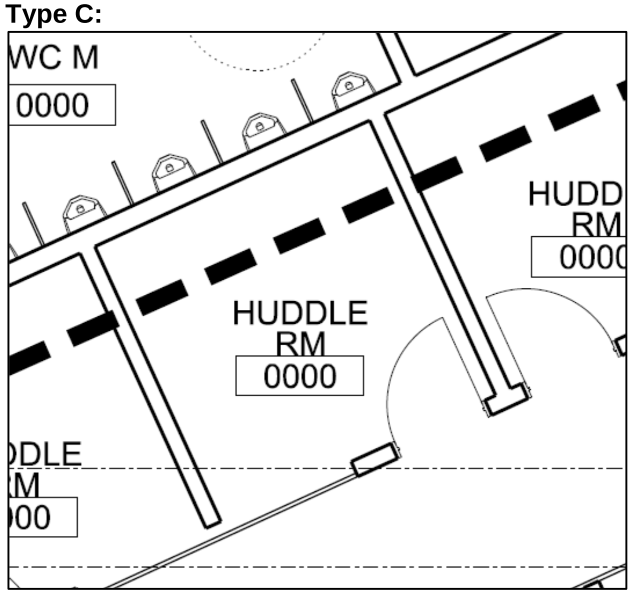
Type B:



These rooms do not have acoustic privacy requirements. Speech may be heard and possibly understood where the speaker and subject matter are known.

All huddle rooms at the façade are Type B. All huddle rooms on the ground floor are Type B.

Type C:



The spaces can be reserved as cellular offices or as informal meeting spaces. The acoustic design for this room is such that normal speech is not intelligible in an adjacent huddle room. Speech to/from the corridor may be intelligible.

Huddle rooms at the center core of the building are Type C.

Walls

Type B and C: Adjacent Huddle rooms will be separated by 4 layers of GWB on single steel stud (Refer to Type A4 in A-

005 for detail).

Type B: Glazing to corridor will be a butt glazed system with minimum 3/8 inch laminated glass.

Type C: Glazing to corridor will be a framed glass system with minimum 3/8 inch laminated glass. The glass will be framed into a gypsum wall system with minimum 2 total layers of 5/8 inch gypsum.

Type C: Flanking sound transmission through the demising wall intersections to the front wall. The joints should be

- Airtight
- Min ¾" solid steel
- Have a break or butt joint in the glazing at the intersection.

Type C: Adjacent shaft spaces and plumbing walls should be separated from huddle rooms by a shaftwall with minimum 6" Stud (Refer to Type D3 in A-005 for detail).

Doors

Type B: Min 3/8in laminated glass, head and jamb gasket seals

Type C: Insulated hollow steel doors, head and jamb gasket seals, automatic drop door bottom seals

100% CD Update: For Type C rooms, honeycomb metal doors will be used and metal door frames will be packed with fiberglass insulation to prevent flanking.

Impact Isolation

Current design is showing carpet in all huddle rooms for impact isolation purposes.

Finishes

Minimum of 2 adjacent walls with tackable sound absorbing panels. Basis: 1 inch fabric wrapped fiberglass (NRC0.80) from 3 feet A.F.F. to door height.

HVAC Design

Supply should be ducted to the rooms. VAV boxes should not be located within the rooms.

Types B and C: Return air paths can have transfer ducts to a corridor plenum if duct is minimum 24 inches in length and lined with 2" duct liner and includes 2 elbows. Transfer ducts should NOT be used between adjacent huddle rooms.

4.9.20 MECHANICAL ROOMS

Typical Recommendations

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
N/A	N/A	STC 60 - 65	0.7 to 1.0 seconds

B1 Pump Room:

A portion of the pump room on Level 0 is directly below the Lecture Hall. Due to the high noise levels from the equipment in this room, we recommend the following:

- The basement pump room should have approximately 50% of the walls and ceilings treated with 2-in thick perforated metal sound absorbing panels with bagged-fiberglass backing. Kinetics Noise Control KNP panels or equivalent. Alternatively, black tissue faced fiberglass may be used.

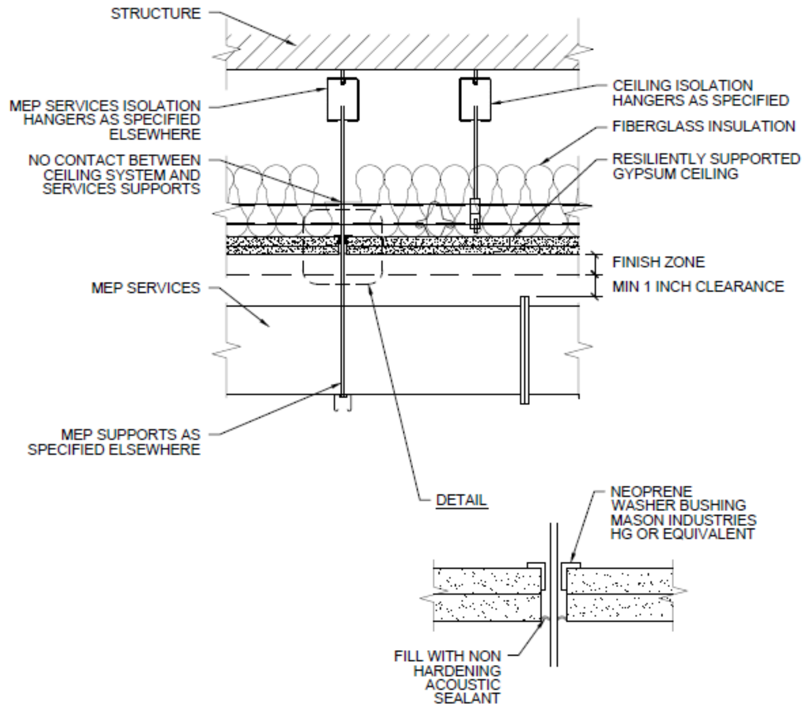
- Doors should be minimum STC45 steel doors.

  100% CD Update: Hollow metal doors and metal door frames will be packed with fiberglass insulation to prevent sound transmission and flanking.

- Walls should be minimum 8-in thick grouted CMU walls.

  100% CD Update: Mechanical room walls to adjacent corridor/lobby will be 4 layers of 5/8” GWB on separate steel studs.

- Resiliently supported gypsum ceilings (see detail below):



100% CD Update: Resilient ceiling will only cover portion of slab overlapping Lecture Hall. Detail has been coordinated and will be shown on architectural drawings.

- Vibration isolation for all equipment:
  - All end suction/split case pumps on concrete inertia bases and 2 inch deflection springs.
  - Double sphere molded rubber flexible connectors should be used on all end suction and split case pumps.
  - Heat pumps on steel bases with 2 inch deflection springs.
  - Miscellaneous fans on spring or neoprene mounts/hangers.

50%CD Update: 2-inch thick fiberglass or rockwool sound absorbing treatment on 1600 square feet of the basement pump room, evenly distributed on minimum 50% of the hung ceiling surface.

100% CD Update: Exposed slab areas (area not covered with resilient soffit) will be treated with 2 inch thick ductliner.

<u>Rooftop AHU Room:</u>

The ducted noise levels from the AHUs in the rooftop mechanical space are extremely loud. Therefore we recommend the following to prevent excessive noise from being transmitted out through the louvers into the environment and also through the ducts to the rest of the building.

- Minimum 5 foot long silencers at all AHU outside, exhaust, supply and return paths. **50%CD Update:** Silencer schedule coordinated with mechanical engineer.

- Vibration isolation for all equipment:

  - AHU internal fans on 2 inch deflection springs.
  - AHU casing on neoprene waffle pads.
  - Miscellaneous fans on spring or neoprene mounts/hangers.

Additional silencers and duct lining may be required after a full mechanical review at the beginning of the next phase.

<u>Generator Room:</u>

The generator room should include the following:

- Provisional 7 to 10 foot long silencers at all generator room façade intake and exhausts.

- Critical grade flue muffler for generator

- Steel skid on 1 inch deflection restrained spring isolators.

100% CD Update: Generator silencer requirements have been coordinated with mechanical engineer.

<u>Additional Cornell Standard Requirements</u>

We assume the Cornell University Facilities Services Design and Constructions Standards will govern the Universities acoustic requirements unless otherwise noted by the Client. http://cds.fs.cornell.edu/

The primary acoustic requirements noted in this standard are:

- The Designer should apply good practice and design the air handlers, ductwork, and piping systems so as to create a quiet system appropriate for the specific project. Sound and vibration criteria should be defined early in the project and documented in the Design Intent and developed with the Basis of Design.

- Generally, classroom and office environments are designed to meet NC30, and laboratories designed to meet NC50.

- MERs above the lowest floor shall be curbed and all floor penetrations sleeved to 2-in above the floor. Thermally and acoustically insulate MERs under occupied areas. Provide thermostatically controlled ventilation as required. Waterproof MER floors above all occupied areas.

- The use of acoustic lining shall be minimized. Sound traps are the preferred method of sound attenuation. Lining in medium and high velocity ducts shall have perforated metal cover (i.e., double wall construction). Exposed lining is acceptable downstream of VAV boxes only. If used, acoustic lining shall be installed to the latest SMACNA standards. It shall be rated to prevent fiber erosion at air velocities up to 4,000 FPM and shall have a minimum density of 1.5 pounds per cubic foot. The liner must be installed with sheet metal nosing at the leading edge. Exposed edges-including butt joints - shall be sealed with mastic.

- The use of flexible elastomeric insulation on ductwork is permitted as an acceptable alternative to fiberglass. Insulation shall be adhered to 100% of the duct surface area.

- AHUs: (Summarized for brevity): Draw-through, self-supported plenum fans preferred. Internally spring isolated on a structural steel base complete with flex connections and lateral restraint. Direct drive self-supported fans (with variable speed drives) are preferred over belt drive fans. Fan sections typically have perforated inner walls for sound attenuation. All supply outlets and air intakes should incorporate factory bell-mouth transitions in the AHU wall. Double skin AHU casing.

- In air distribution system, duct lining shall not be used without perforated metal liner.

- We encourage duct sizing for low velocity (less than 1500 ft/min. Duct static pressure should also be kept as low as possible through low velocity duct sizing, minimizing duct bends, and selection of terminal boxes and outlets for low pressure drop.

- Outdoor enclosures for emergency generators shall be sound attenuated; coordinate specific dB(A) limits with CU FE during design. Provide hoods as required to meet required sound levels. Generator exhaust piping and muffler shall be installed and contained within the enclosure. The exhaust outlet only shall be extended through the enclosure.

4.9.21 RESTROOMS

Background Noise	Impact Isolation from Above	General Sound Isolation	Reverberation Time
NC 45 - 50	N/A	STC 50 - 55	N/A

<u>Walls</u>

Walls should be full height. Walls with plumbing should be constructed per the detail below.

<u>Plumbing and Fixture Isolation</u>

Some fixture and plumbing may require resilient support if located nearby sensitive space.

Also refer to the lecture hall section of this report. We do not recommend locating restrooms directly adjacent to the lecture hall. Even with resilient supports, it may not be feasible to render plumbing noise inaudible in the lecture hall.