Project Documentation

1 Abstract

R-951 Residence: Three Family Passive House Building

1.1 Data of building

Year of construction	2013	**Space heating / Heizwärmebedarf**	**14.8 kWh/(m²a)**
U-value external wall/ U-Wert Außenwand	0.112 W/(m²K)		
U-value basement ceiling/ U-Wert Kellerdecke	0.298 W/(m²K)	**Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)**	N/A

U-value roof/ U-Wert Dach	0.084 W/(m²K)	**Generation of renewable energy / Erzeugung erneuerb. Energie**	N/A
U-value window/ U-Wert Fenster	0.86 W/(m²K) (average)	**Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)**	109 kWh/(m²a)
Heat recovery/ Wärmerückgewinnung	80.1 %	Pressure test n_{50} / Drucktest n_{50}	0.56 h-1
Special features/ Besonderheiten	PV Array (not used in PHPP calcs). Certified Net Zero. Rainwater collection for irrigation. Reclaimed Wood.		

1.2 Brief Description ...

R-951 Residence: Brooklyn, NY

The R951 Rowhouse is the first certified Passive House, certified Net Zero capable building in New York City. Completed in 2013, it is currently fully occupied. The building contains three duplex units. Unit 1 connects the basement/garden level to the 1st floor. Unit 2 connects the 2nd floor with a rear 2nd floor mezzanine. Unit 3 connects the 3rd floor to the 4th floor penthouse. The dynamic section demonstrates that Passive House design can lend itself to exciting, light-filled spaces. Additionally, each unit has access to at least two private exterior spaces.

The front façade of the building faces south. The thermally broken balcony/sunscreen system on this façade allows users to manage solar gain and is an expression of the design intent of the project. The building's primary structural system is insulated concrete forms which provide superior air sealing and thermally broken insulation. Additional insulation was provided at the front and rear facades.

The 13.5 kW solar array was not needed for Passive House certification, but allows each unit to be Net Zero capable. The solar can power a circuit within each unit in the event of a power outage. Finally, the roof rainwater is collected on site and re-used for irrigation.

1.3 Responsible project participants / Verantwortliche Projektbeteiligte

Architect/ Entwurfsverfasser	Paul A. Castrucci, Architect https://www.castrucciarchitect.com/
Implementation planning/ Ausführungsplanung	Grayson Jordan, Architect (Project Architect – Paul A. Castrucci, Architect) https://www.castrucciarchitect.com/
Building systems/ Haustechnik	Jordan Goldman – Zero Energy Design http://zeroenergy.com/
Structural engineering/ Baustatik	Santora Engineering, PC
Building physics/ Bauphysik	Grayson Jordan, Architect (Project Architect – Paul A. Castrucci, Architect) https://www.castrucciarchitect.com/
Passive House project planning/ Passivhaus-Projektierung	Grayson Jordan, Architect (Project Architect – Paul A. Castrucci, Architect) https://www.castrucciarchitect.com/
Construction management/ Bauleitung	

Certifying body/ Zertifizierungsstelle	Passive House Institute http://passiv.de/en/
Certification ID/ Zertifizierungs ID	4492 (http://www.passivhausprojekte.de/index.php?lang=en#d_4492)

Author of project documentation / Verfasser der Gebäude-Dokumentation	Grayson Jordan, Architect (Project Architect – Paul A. Castrucci, Architect) https://www.castrucciarchitect.com/
Date, Signature/ Datum, Unterschrift	4·17·17

2 Views of R-951 Passive House

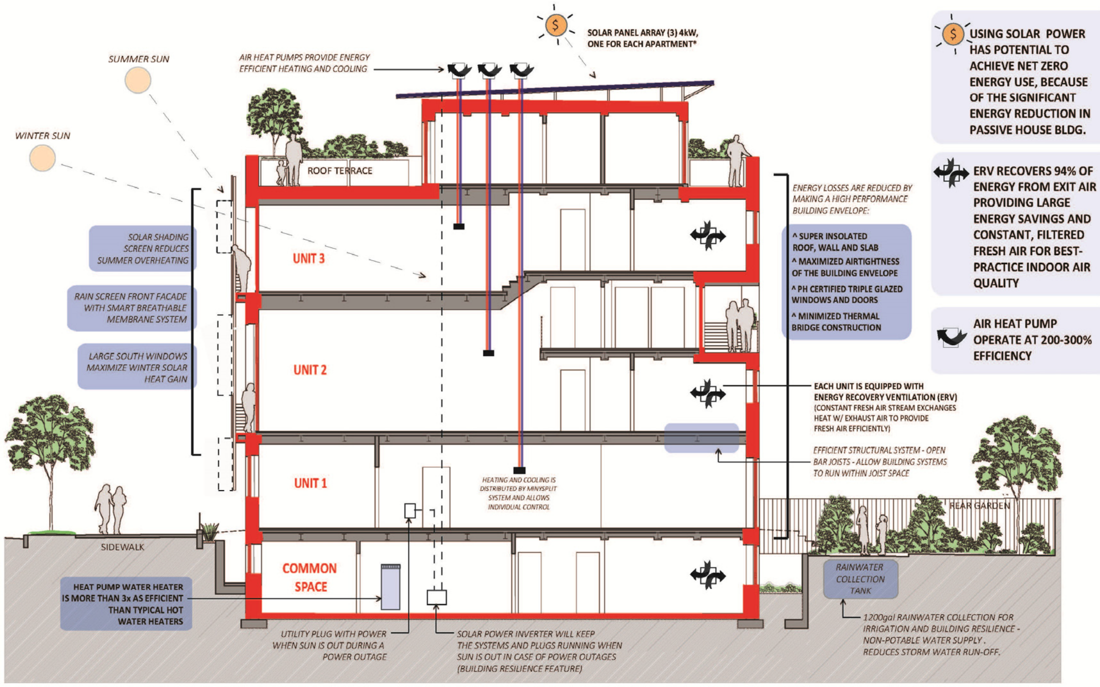
South (Front) Facade

South and angled view of East Facade
(NOTE: Adjacent Building at West Facade)

North (Rear) Facade

Interior View – Apartment 2

3 Sectional view of R951 Residence

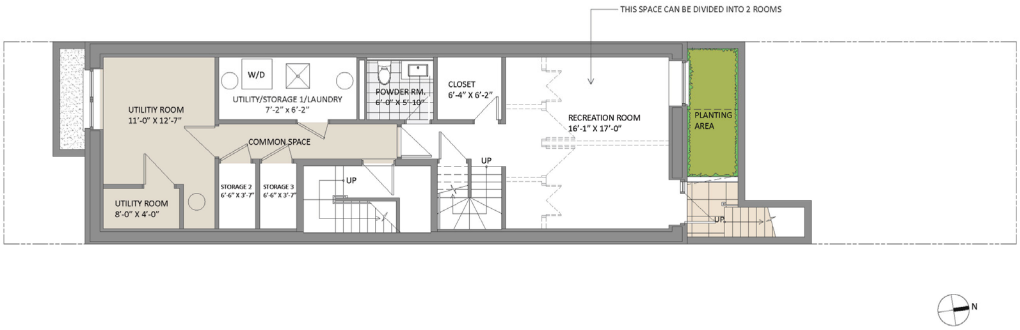


The sectional view shows a well defined thermal envelope. All exterior surfaces have exterior insulation so that the thermal envelope continues along he exterior face of the insulation at the walls, over the roof, as well as under the slabs. Air sealing is accomplished by taping air membranes and concrete surfaces at wall/slab and wall/roof edges. The building takes advantage of its southern exposure with large south facing windows coupled with operable solar screens, and a 13.5 kW solar array.

Each unit has its own ERV unit, which is shown diagramatically in the section. Each unit has a heat pump unit – all heat pumps are located on the roof. The building's hot water is supplied by heat pump hot water heaters. Rainwater is collected on site for irrigation.

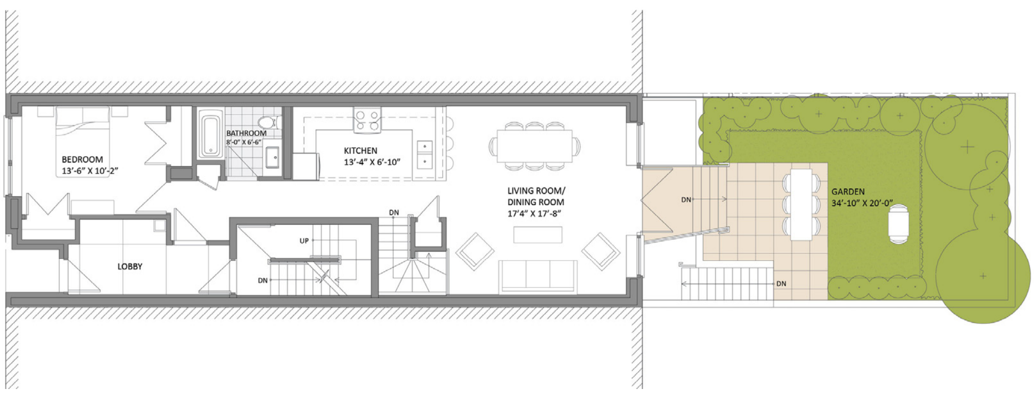
4 Floor Plans of R-951 Passive House

Apartment 1 – Lower Level Plan



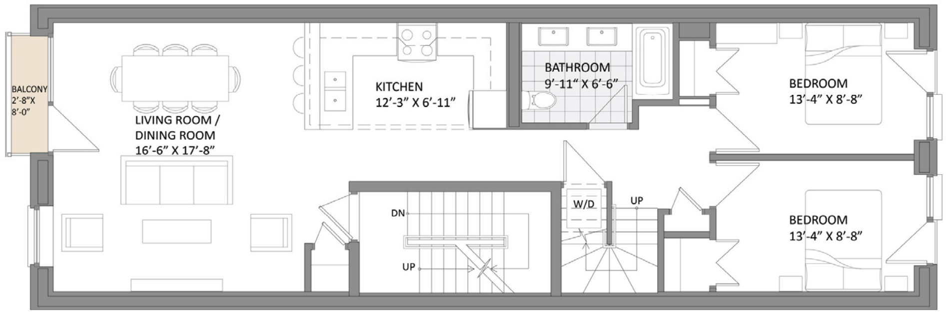
The lower level of Apartment 1 is the basement of the building. To the North (right on the plan) is the lower level of the apartment 1 duplex. This level has a recreation room with access to a rear garden, closet space and a bathroom. On the South (left on the plan) are utility rooms (with meters and hot water heaters) and storage.

Apartment 1 – Upper Level Plan



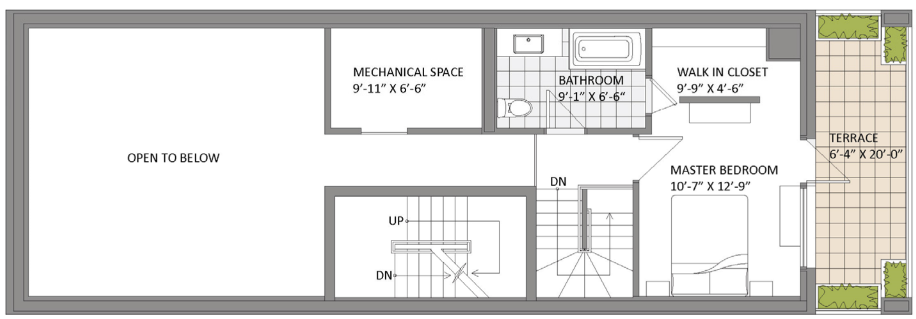
The upper level of Apartment 1 is the 1st floor of the building. This level is a floor-through apartment with a bedroom on the South (right) and an open living area/kitchen on the North (South). The living area has a large glass opening to the rear garden. The main building entry is at the South of this level, with connection to the building egress stairs at the center of the building.

Apartment 2 – Lower Level Plan



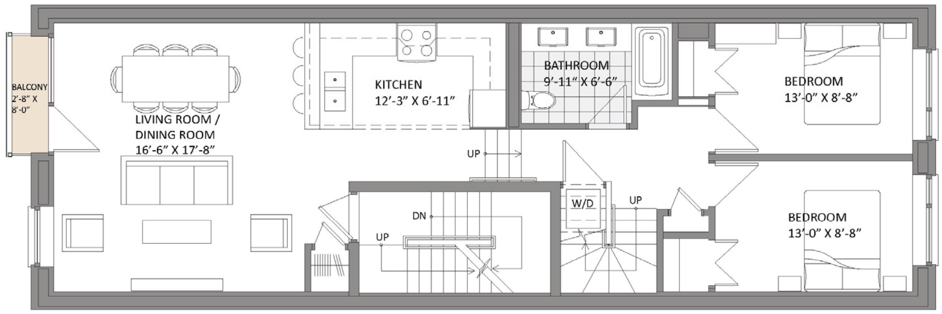
The lower level of Apartment 2 is the 2nd floor of the building. This level is a floor-through apartment with an open living room/kitchen on the South. The living room has large, south facing windows. A juliet balcony gives the occupants access to the operable screens to control solar gain. To the North of this floor are two bedrooms, a bathroom, and stairs to the upper level of the duplex. The building egress stairs are located in the center of the space.

Apartment 2 – Upper Level Plan



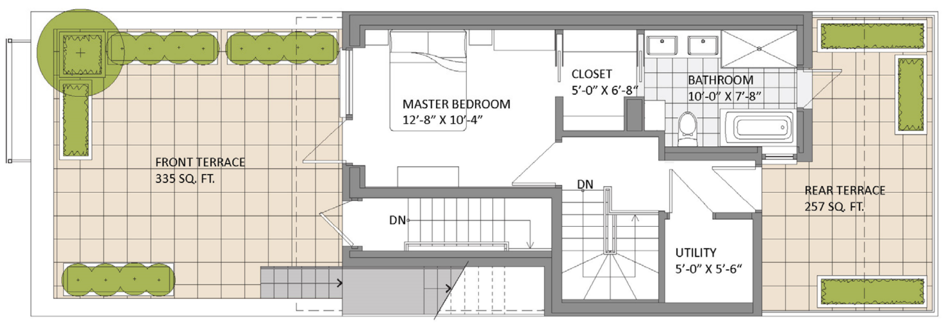
The upper level of Apartment 2 is the Mezzanine of the building. To the south, this level is open to the living room below, creating a dynamic double-high space. A mechanical space is located above the kitchen below. To the North, a Master bedroom and Master Bath open unto a rear terrace, carved into the rear of the building.

Apartment 3 – Lower Level Plan



The lower level of Apartment 3 is the 3rd floor of the building. This level is a floor-through apartment with an open living room/kitchen on the South. The living room has large, south facing windows. A juliet balcony gives the occupants access to the operable screens to control solar gain. To the North of this floor are two bedrooms, a bathroom, and stairs to the upper level of the duplex. The building egress stairs are located in the center of the space.

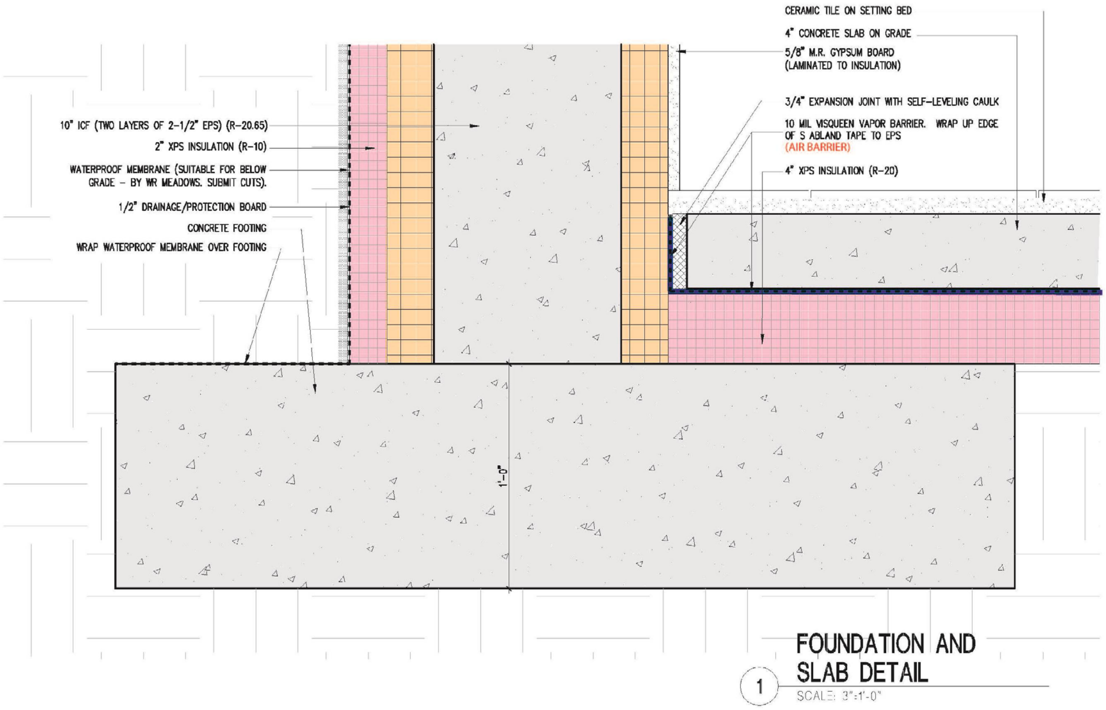
Apartment 3 – Upper Level Plan



The upper level of Apartment 3 is the 4th Floor/Penthouse of the building. To the south, a common terrace looks out over the street. This terrace also has stairs that connect to the upper roof terrace and solar panels below. In the center is the 4th floor, with a Master Bedroom and Master Bath connecting to a private rear terrace. This floor also has a utility room for the unit.

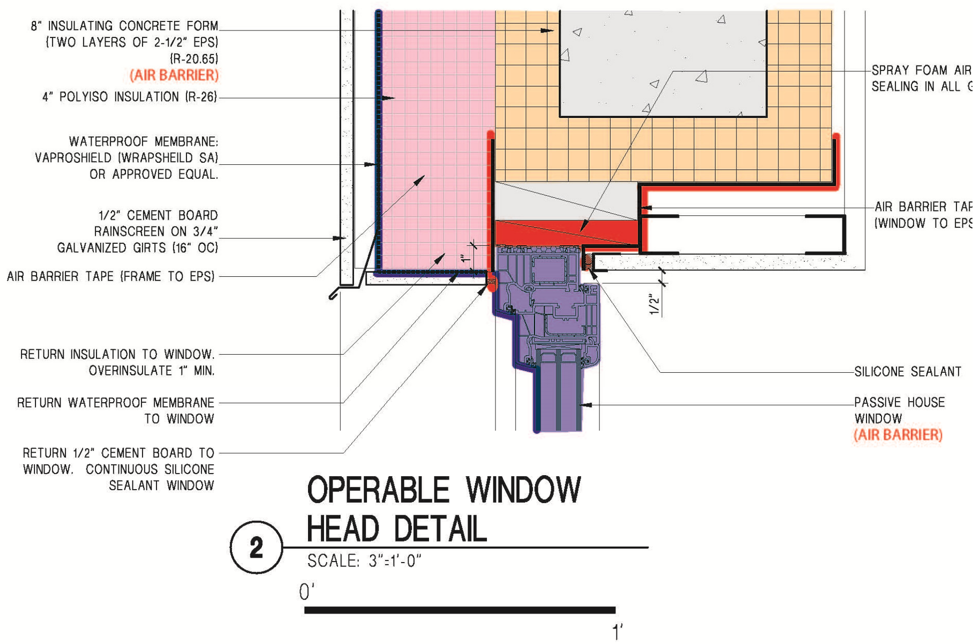
5 Construction Details of Envelope of R-951 Passive House

5.1 – Basement Slab Construction



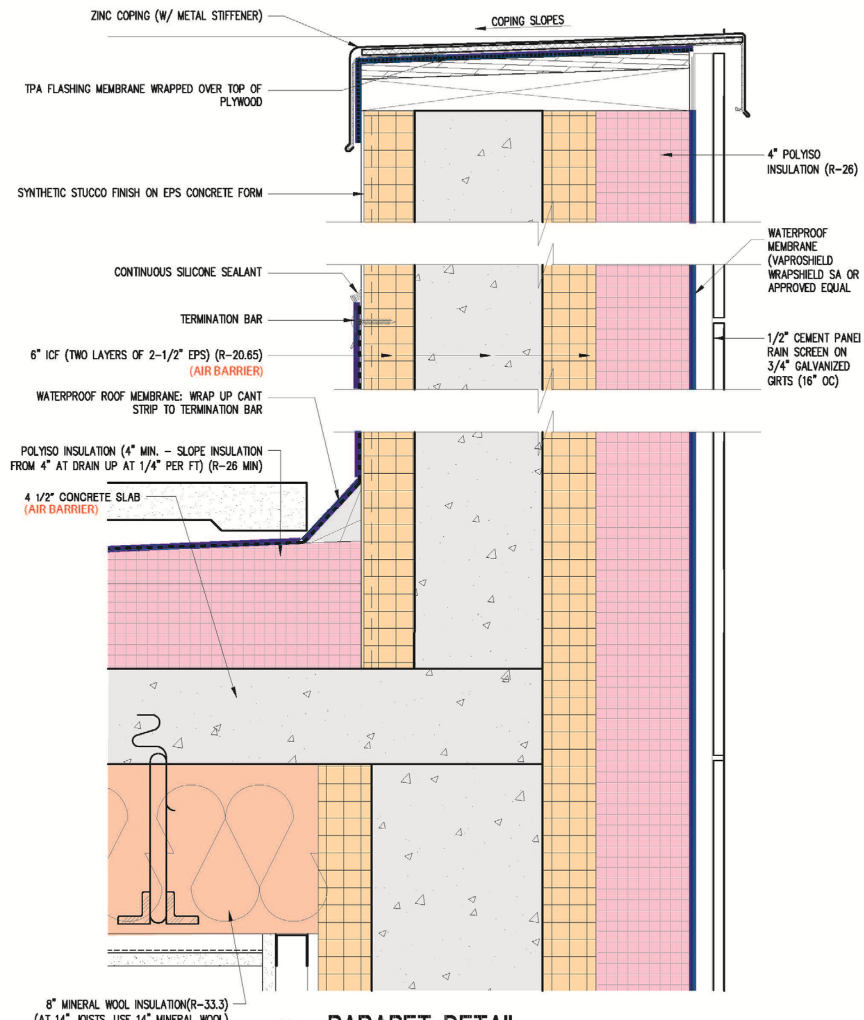
A footing was required for this project, and the exterior insulation could not wrap the footing. The ICF construction helped mitigate this thermal bridge by providing 2.5“ of EPS insulation on the inside of the concrete wall. This ICF connects to the 4“ of XPS insulation below the slab, creating a continuous insulation plane between the concrete fooing and the tempered interior space. The vapor barrier at the slab is taped to the EPS insulation continuously around the slab.

5.2 – Exterior Wall Construction



The exterior walls are constructed using ICF (Insulated Concrete Form) construction. The ICF consists of two (2) layers of 2.5“ EPS forms, with 8“ reinforced concrete poured between the forms. This base construction type provides continuous insulation and excellent air sealing. At the front wall, the ICF is augmented with 4“ polyiso insulation. On the rear facade, the ICF is augmented with 4“ EIFS. There is no additional insulation at the side facades due to the spatial limitations of the rowhouse typology.

5.3 – Roof Construction



1 PARAPET DETAIL

SCALE: 3"=1'-0"

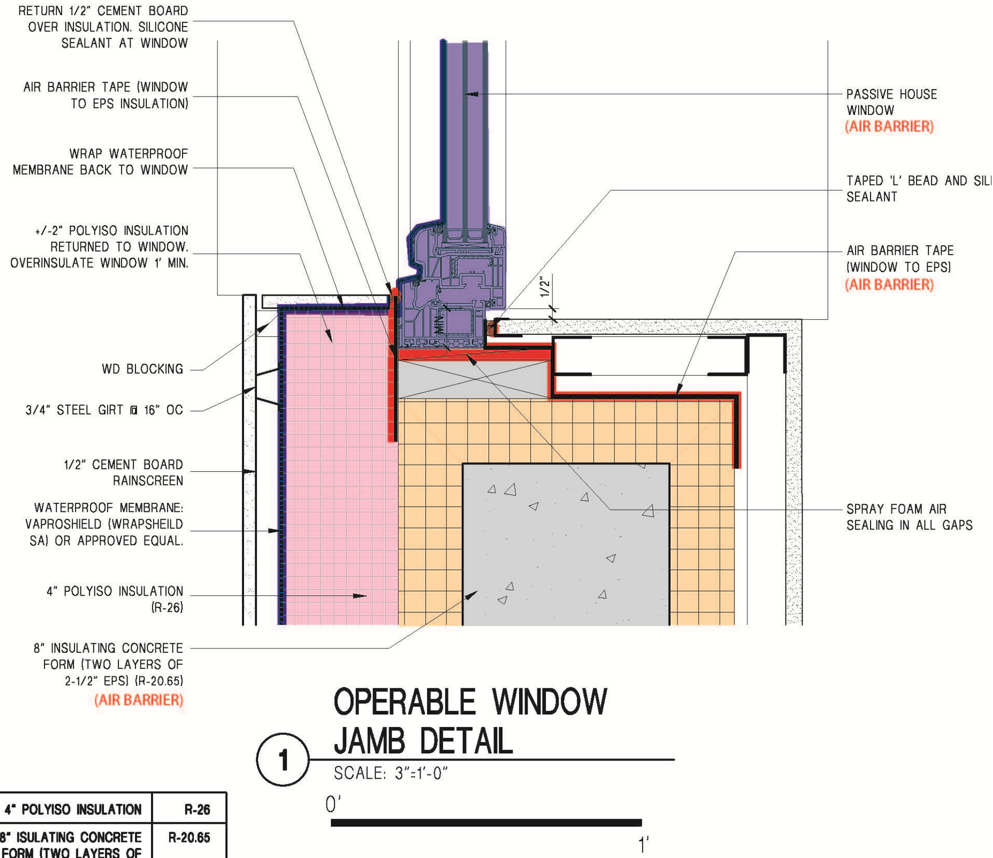
0' 1'

4" POLYISO INSULATION	R-26
8"MINARAL WOOL INSULATION	R-33.33
TOTAL:	R-59.33

4" POLYISO INSULATION	R-26
8" ISULATING CONCRETE FORM (TWO LAYERS OF 2-1/2" EPS)	R-20.65
TOTAL:	R-46.65

The roof structure is composed of steel bar joists with a 4“ concrete slab. On top of the slab is continuous polyiso insulation. The polyiso insulation is tapered to the drains, and ranges from 4“ to 6“ in thickness. Under the slab, 8“ of mineral wool batt insulation is placed between the bar joists, which are +/- 48“ oc. To mitigate the thermal bridge at the parapet, the parapet is poured with ICF, creating a thermal break up to the cap of the parapet. The cap of the parapet is not insulated, but the interior face of the ICF and the mineral wool help reduce the effects of this thermal bridge.

5.4 – Window Type and Installation



4" POLYISO INSULATION	R-26
8" ISULATING CONCRETE FORM (TWO LAYERS OF 2-1/2" EPS)	R-20.65
TOTAL:	R-46.65

The windows for the project are all triple pane, vinyl windows by Schuco. The glazing U-Value is 0.5 w/m^{2}k. The frame U-Value is 1.0 w/m^{2}k. The windows are installed in plane with the outer face of the ICF's insulation. The additional exterior insulation (polyiso at the front, EPS at the rear) is installed over the frame edge per the detail above. The windows are taped to the ICF insulation, as well as to a waterproof (and air tight) membrane outboard of the polyiso.

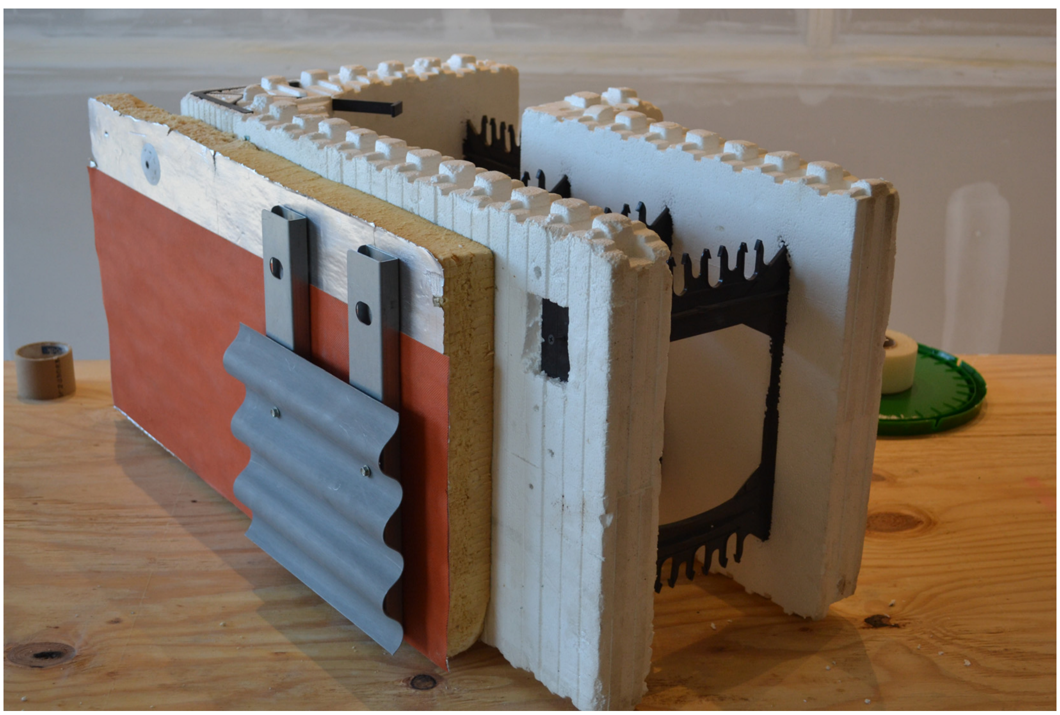
The south-facing facade of the project has additional glazing to harvest the warm winter sun. These enlarged windows an be shaded by an operable metal screen on the front juliet balconies, minimizing heat gain in the summer.

Window Type=	Schuco PVCU
U-Value of Frame =	1.0 w/m^{2}k
U-Value of Glazing =	0.5 w/m^{2}k
Construction Type of Window=	Thermally broken vinyl frames, triple pane glass, casement and fixed windows
g-value of Glazing =	0.5

Airtight Envelope of R-951 Passive House

6.1 – Air sealing tape at window

6.2 – Mock-up showing ICF construction (primary air barrier) and exterior waterproof membrane (secondary air barrier



The ICF construction is the first level of air tightness for the project. The ICF wraps all four walls, and is taped to the windows as well as the air membranes at the roof and the basement slab. A secondary air membrane is installed at the front facade, and is taped to the windows as well s the air membranes at the roof and the basement slab. The project passed the air tigtness test, with 0.56 ACH/50.

6.3 – Blower Door Test Results

Building Leakage Test

Computation based on EN 13829 Method B

Project Address	951 Pacific Street	**Client**	Paul Castrucci Architect
	Brooklyn, NY 11238		**Ph.** 212.254.7060
		Contact Person	Paul Castrucci
			Ph. 212.254.7060

Measured Data :

Test performed by: Jordan Goldman **Date:** 2/19/15

Ventilated Volume	1161	m³ / ft³
Heated Floor Area	347	m² / ft²
Building Envelope Area	1066	m² / ft²
Inside Temperature	16.0	°C / °F
Outside Temperature	-7.0	°C / °F

Comments

Depressurization

Note:

Fan Configuration	Nominal Building Pressure	Fan Pressure	Nominal Flow	Margin of Error
Ring	[Pa]	[Pa]	[m³/h] [cfm]	[%]
Blower closed	-4.5	—	—	—
1	65.0	148.0	853	-8.21
1	58.1	114.0	748	-9.26
1	49.5	108.0	728	4.63
1	37.6	57.0	528	0.91
1	31.8	55.0	518	17.49
1	23.3	32.0	394	21.47
2	15.0	42.0	172	-20.32
Blower closed	-4.5	—	—	—

Correlations Coefficient	r =	0.96162
Building Coefficients [m³/hPa], norm.	C_0 =	6.4
Building Exponent	n =	1.148

Pressurization

Note:

Fan Configuration	Nominal Building Pressure	Fan Pressure	Nominal Flow	Margin of Error
Ring	[Pa]	[Pa]	[m³/h] [cfm]	[%]
Blower closed	-4.5	—	—	—
1	73.0	172.0	920	-1.99
1	63.2	139.0	827	-3.55
1	57.9	114.0	748	-7.78
1	44.6	121.0	771	11.72
1	39.0	94.0	679	6.76
1	32.5	64.0	559	-1.88
1	28.2	66.0	568	8.32
1	18.6	29.0	375	-9.50
Blower closed	-4.5	—	—	—

Correlations Coefficient	r =	0.96289
Building Coefficients [m³/hPa], no	C_0 =	51.8
Building Exponent	n =	0.675

Results, Characteristic Values :	ACH n_{50}	Margin of Error	Air Flow V_{50}	NBV_{50}	q_{50}	ELA_{4Pa}
	h^{-1}	%	m³/h	m³/m²h	m³/m²h	cm²
Depressurization	**0.49**	+/- 16.42	574	1.7	0.54	34
Pressurization	**0.63**	+/- 6.75	726	2.1	0.68	142
Average from negative & positive pressure	**0.56**		650	1.9	0.61	88
Maximum allowed value	**0.6**					

Enforcing Code: Passive House Standard

6 Ventilation System of R-951 Passive House

7.1 – Ventilation ductwork

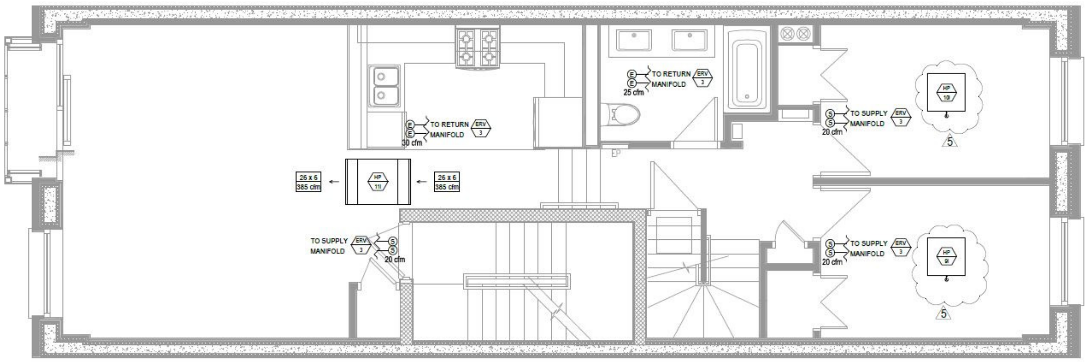
Each of the three apartments had their own ERV system. The ERVs were placed in the respective units to mimize duct runs for the ventilation system. Supply air was provided to the Living Rooms and Bedrooms. Extract air was taken from the bathrooms and kitchens. Ductwork for the ERV was primarily 3" flexible ducting run in the ceiling and terminating with clean, modern registers at the ceiling or wall.

7.2 – Ventilation central unit

As described above, each of the three apartments had their own ERV system. The ERVs for each unit are the same make model, with specifications as follows:

- Manufacturer: Zehnder
- Model #: Comfoair 350
- Capacity: 350 CFM
- Effective Heat Recovery: 80%
- Electrical Efficiency: 0.29 Wh/m^3

7.3 – 3rd Floor Mechanical Ventilation Plan



1 THIRD FLOOR MECHANICAL PLAN
$\frac{1}{4}$" = 1'-0"

VENTILATION LEGEND

Ⓔ EXHAUST POINT

Ⓢ SUPPLY POINT

EACH EXHAUST AND SUPPLY POINT IS CONNECTED TO ITS RESPECTIVE HRV DUCT MANIFOLD WITH 3" FLEXIBLE HDPE DUCT (SUPPLIED BY ZEHNDER). A TRIPLE Ⓔ OR Ⓢ SYMBOL INDICATES THAT TWO DUCTS ARE PROVIDED. A DOUBLE Ⓔ OR Ⓢ SYMBOL INDICATES THAT TWO DUCTS ARE PROVIDED. A SINGLE Ⓔ OR Ⓢ SYMBOL INDICATES THAT ONE DUCT IS PROVIDED. VENTILATION DUCTS AND REGISTER BOXES SUPPLIED BY ZEHNDER. REFER TO DRAWINGS TO DETERMINE WHETHER A ZEHNDER DIFFUSER BOX 'TVA' w/ A ZEHNDER SUPPLY / RETURN DIFFUSER OR A ZEHNDER REGISTER BOX 'CLD' w/ A ZEHNDER GRILL COVER IS USED.

Heat Supply System of R-951 Passive House

8.1 – Two of three total heat pumps on the project

8.2 – Heat Pump Hot Water Heater

Each apartment is equipped with its own mini-split heat pump for heating and cooling. Each heat pump has 3 tons of capacity, and handles heating and cooling for the respective apartments. A refrigerant line runs from the outdoor units to air handlers located within the ceilings of the interior bathrooms. Sheet-metal ductwork provides tempered air to the living spaces and kitchens. Specifications of the heat pumps are as follows:

- Manufacturer: Mitsubishi
- Model #: Slim MXB-4B36NA
- Capacity: 34,400 BTUH cooling, 20,300 BTUH heating
- COP: 2.7
- SEER: 16.5

Each apartment also is equipped with its own hot water heater. The hot water heaters are efficient heat pump hot water heaters, with the following specifications:

- Manufacturer: Stiebel Eltron
- Model #: Accelera 300
- Capacity: 80 gallons
- Energy Factor: 3.2

7 Documentation of Important PHPP Results

The result of the project was a passing project per PHPP verification. The energy modeled results and inputs are as follows:

Primary Energy Demand:	109 kWh/m^2a
Space Heating Demand:	14.8 kWh/m^2a
Space Cooling Demand:	12.5 kWh/m^2a
Air Tightness:	0.56 ACH50
Treated Floor Area =	347 m^2
Building Type:	Residential
Utilization Pattern:	Dwelling
Mechanical Cooling?:	Yes

Passive House verification

Photo or Drawing

Building:	Shutter House
Street:	951 Pacific Street
Postcode / City:	Brooklyn, NY 11238
Country:	USA
Building type:	Three Family Residential
Climate:	NY, New York — Altitude of building site (in [m] above sea level): –
Home owner / Client:	951 Pacific Street, LLC
Street:	951 Pacific Street
Postcode/City:	Brooklyn, NY 11238
Architecture:	Paul Castrucci, Architect
Street:	179 Rivington Street, Suite 1A
Postcode / City:	New York, NY 10002
Mechanical system:	Jordan Goldman
Street:	156 Milk Street, #3, Boston MA 02109
Postcode / City:	Boston, MA 02129

Year of construction:	2013	Interior temperature winter:	20.0	°C	Enclosed volume V_e m³:	387.1
No. of dwelling units:	3	Interior temperature summer:	25.0	°C	Mechanical cooling:	x
No. of occupants:	9.9	Internal heat sources winter:	2.1	W/m²		
Spec. capacity:	204 Wh/K per m² TFA	Ditto summer:	3.8	W/m²		

Specific building demands with reference to the treated floor area

				Requirements	Fulfilled?*
	Treated floor area	347.1	m²		
Space heating	Heating demand	14.79	kWh/(m²a)	15 kWh/(m²a)	yes
	Heating load	11	W/m²	10 W/m²	-
Space cooling	Overall specif. space cooling demand	12.50	kWh/(m²a)	17 kWh/(m²a)	yes
	Cooling load	9	W/m²	-	-
	Frequency of overheating (> 25 °C)		%	-	-
Primary energy	Heating, cooling, auxiliary electricity, dehumidification, DHW, lighting, electrical appliances	109	kWh/(m²a)	120 kWh/(m²a)	yes
	DHW, space heating and auxiliary electricity	43	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	0.6	1/h	0.6 1/h	yes

* empty field: data missing; '-': no requirement

Passive House?	**yes**

We confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this application.

PHPP Version 8.4

Name:	**Registration number PHPP:**
Surname:	**Issued on:**
Company:	**Signature:**

PHPP, Verification — 3131 Certification

8 Building Cost

The construction cost of the building was approximately $300/sf, with a total cost of approimately $1.35 million. It should be noted that this cost includes the Solar Panels, which were not required for Passive House and not included in the PHPP results.

The escalated cost of the Passive House construction is estimated to be 5%. Of this, a very small portion of the cost is the air sealing and insulation above energy code requirements. Most of the additional cost is related to the triple pane windows and additional requirement for an ERV system. However, because of a local zoning ordinance that gives floor area bonuses for energy efficient construction, an additional 8% of floor area was built, balancing out the developer's cost to go with Passive House.