NCSEA

10/5/01

LESLIE ROBERTSON - LEAD

WORLD TRADE CENTER (9-11-01)

50 EMPLOYEES (1/3 WOMEN)

TUBULAR FRAME PERIMETER
ALL LATERAL FORCES

OUTRIGGER TO INTERIOR

400' + TALL MAST

WIND TUNNEL STUDY

MOTION SIMULATIONS FOR MOTION - PEOPLE

DAMPING SYSTEM

BREAKAGE RATE OF GLASS

EFFECTIVENESS OF ELEVATORS

SHAFT WALL PARTITION SYSTEM

IBM PUNCH CARDS - STEEL FABRICATION
SHOP DRAWINGS

$250,000 WIND TUNNEL TESTS
(NOW WOULD BE $40K)

39 FABRICATORS

600 GAL OF WATER IN COL DURING CONST
- FAIRE - SPLIT COL - REQUIRED

1/3 OF COL SPLICED IN ANY STORY
STAGGERED CONNECTIONS

SPANREL PL THICKER THAN COL

10' X 65' PANELIZED FLOOR SYSTEM

THROUGH BOLTED COLUMN SPLICES
W/ ACCESS HOLES

THERE HAVE BEEN SEVERAL FIRES
IN THE TRADE CENTER

5 ENGINEERS VERIFYING QUALITY
CONTROL DURING CONST.

PERIMETER FRAME - COLUMNS ~ 5' ∝ ±

1ST SHAFT WALL

NO DEPTHS DURING CONST.

ALL ON LAND FILL

TOWER ON TOP BASED DURING CONST.

1993 BOMBING - 6' FROM N. TOWER
B2 LEVEL

AIR LOCK DESTROYED
TO NEUTRALIZE AIR PRESSURE

SMOKE SUCKED UP THROUGH TOWERS

AIR CONDITIONING - REPLACED W/ EMERG.

UNBRACED LENGTH OF COL
BRACED BY DEBRIS
BRACED W/ 6 x 6 TUBES

SURVEY WALLS NO LONGER BRACED

BACK SIDE OF DROP PANEL
BLOWN OUT FROM SHOCK WAVE

COLUMNS HAD X BRACING BELOW GRADE

(2) T'S LAPPED WEBS - BOLTED - FLANGE
CONT. POST COLUMNS.

DEBRIS = CARS, TELEPHONE LINES,
STRUCTURE

9-11-01

59 COL EACH FACE

2/3 DESTROYED IN FACE
MORE ON SIDE & INTERIOR

SHOWED SLIDES OF GROUND 'O'

THE FIRE IS STILL BURNING

MOLTEN METAL - STILL RUNNING (WEB)

MOST DAMAGE FROM COLLAPSE VS BLAST

FIRE & WATER - DESTROY

STEEL BEING RECYCLED (BY BARGES)

4" THICK PLATE STEEL ON SOME COL

COL SHEARED OFF @ B2 LEVEL

NOW 6' OF WATER IN BASEMENT.

3' AFTER BOMBING

BUILDINGS STARTED 40 YEARS AGO

1ST LIKED BY ARCHITECTS
THEN NOT
THEN AGAIN.

BUILDING WAS MOSTLY AIR
LOOKED SOLID - WITH SUN BEHIND IT
YOU CAN SEE HOW LIGHT AND AIRY
IT REALLY WAS.

US STEEL BUILDING AND OTHER
BUILDINGS WERE BEING DESIGNED
AND CONSTRUCTED DURING THIS
PROJECT BY THE FIRM.

707 IMPACT - DESIGN

120 MPH (FROM PORT AUTHORITY)

20 STORY - LARGEST DESIGNED BY LESLIE PRIOR TO THE WORLD TRADE CENTER (B-25, EMPIRE STATE BUILDING)

NO THOUGHT OF TERRORIST.

BUT DID DESIGN FOR ESPIONAGE

PLANE COULD HAVE BEEN GOING 500 MPH. LARGER ENGINES.

STRUCTURE - OK

FIRE !

BUILDING 40 YRS OLD - BUT CURRENT WITH ALL OF TODAYS CODES.

UPWARD FORCE WIND = 4 X SEISMIC FORCE in LA.

SYSTEM - VERY REDUNDANT.

1 ACRE / FLOOR

TEFLON USED BETWEEN PARTITIONS & STRUCTURE FOR SWAY - MOVEMENT.

8" THICK SLAB FOR MECH / ACOUSTICAL REQUIREMENTS

LESLIE ROBERTSON
LERA DESIGNS
10/5/01

THE DESIGN CONCEPT FOR A 500 m BLDG.

1/2 NATIONAL 1/2 INTERNATIONAL

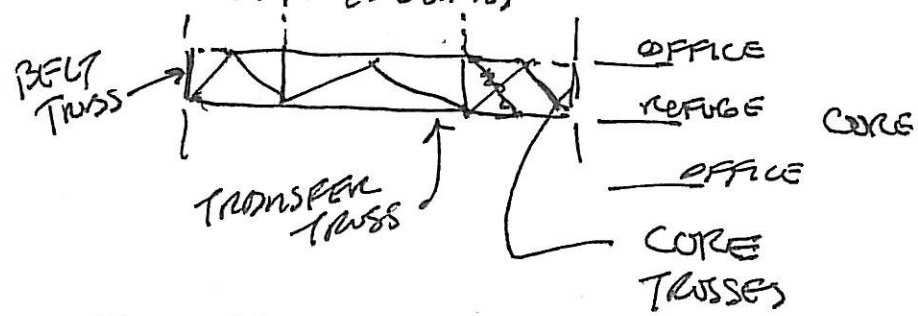
BRACED CORE W/ OUTRIGGERS
MOST COMMON IN FAR EAST

COMPOSITE MEGASTRUCTURE
BANK OF HONG KONG
– (4) COL @ BASE

~NO UPLIFT!

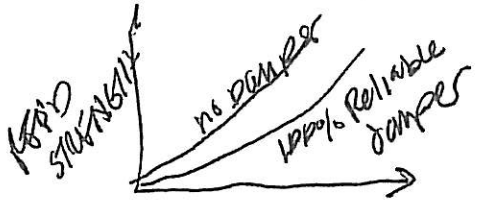
PROPOSED PERIMETER BRACING
OUTRIGGER TRUSSES and
BELT TRUSSES.

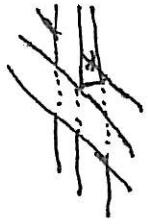
OVERTURNING MOMENT TRANSFERRED
TO EXT. COLUMNS



PERIMETER COL. PASS THROUGH DIAGONALS

ENHANCED DAMPING





TUNED SLOSHING DAMPER SYSTEMS
SSD SHIMZ (~$25 million CHEAPER)

TUNED MASS DAMPERS
- ELECTRIC POWER REQ'D
- SELF CONTAINED - NO POWER REQ'D

ACTIVE DAMPERS
- ELECTRIC POWER REQ'D.

FLOOR FRAMING
VIBRATION

@ PERIMETER JOIST WILL ACT PINNED
@ INTERIOR IT WILL ACT FIXED
W/ NELSON STUDS AND BAR in TOPPING
SLAB ∴ VIBRATION CALC thinks 1 end
IS FIXED! DESIGN PINED PINED.
(FIXED PINNED FOR VIBRATION)

REDESIGNED FLOORS REDUCING 50% WT.

1.0 MF
0.85 BRACED FRAME
0.7% BRACED SYSTEM W/ OUTRIGGERS

STEEL PIPE COLUMNS
OPEN ENDED
DEEPER PILES @ CORE

PERIMETER AND CORE · CONCRETE
SHEAR TRANSFER WALLS

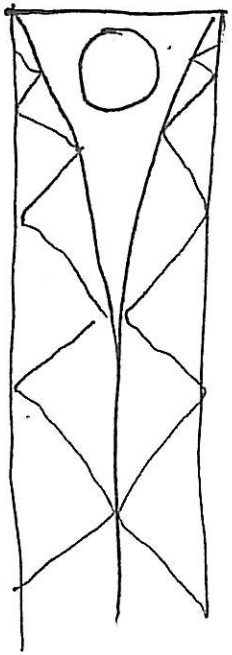
CAN DOP STEEL PLATES TO CONCRETE WALLS INSTEAD OF THICKENING WALL.

PILES CAN BE EXTENDED BY DRIVING NEW PILE INSIDE AND THROUGH OLD PILE

IF BERING IS A PROBLEM – DIG OUT SOIL IN PIER AND FILL W/ CONCRETE

BRACING WILL ONLY BE SEEN AT NIGHT

5-10 lbs / ft^3 – TOTAL BUILD WT.



NCSEA - WORLD TRADE CENTER REPORTS
10/6/01 W Gene Corley
TEAM ORGANIZATIONS
ASCE / SEI
AISC NFPA
ACI SFPE
NCSEA (SOCIETY OF FIRE PROTECTION ENGINEER)

TEAM VISIT WILL VISIT TRADE CENTER SITE TOMORROW!
BUILDING PERFORMANCE STUDIES
IDENTIFY BUILDINGS WHICH WILL BE OR ARE FUTURE TARGETS
E WING Collapse - (PORTION)
D PARTIAL collapse (PORTION)
BUILDING STUDY 20 min.

WTC - TEAM
9 PEOPLE, SE's, materials, fire, etc
EXPERTS + OTHERS
BETTER photographic MATERIAL THAN ANY OTHER ~~"FAILURE"~~ collapse
IMPACT DAMAGE
PHYSICAL DAMAGE VS. FIRE DAMAGE
ERECTION & chalk marks from ORIGINAL CONSTRUCTION - still on SOME MEMBERS

TOWER 1 plane 90th floor ±
TOWER 2 plane 80th floor ±
TUBE IN TUBE CONST.
3'-3" ∞ COLUMN SPACING @ EXT.
LOWER LEVEL
FIRE DEPARTMENT WORKED TO SAVE PEOPLE
SEARCH AND RESCUE – FIRES WERE
CONTROLLED, BUT ALLOWED TO BURN
IN REMAINING BUILDINGS
LARGE ADJACENT BUILDING – MISSING
COLUMN – BUT STILL STANDING
ANOTHER BUILDING – BURNED OUT – BUT
STILL STANDING.
SOME BURNING FROM PLANE –
OTHER BURNING FROM AFTER.
INTENT TO STUDY PERFORMANCE
OF BUILDINGS
POSSIBLY MAKE RECOMMENDATIONS
FOR FUTURE BUILDINGS THAT
ARE POSSIBLE TARGETS OF
TERRORISTS.

SEAOINY

- RESIDENCY ORGANIZED THE NEXT DAY
  VOLUNTEERED TO THE MAYOR'S OFFICE
  AND POLICE DEPARTMENT.

CONTACTED EACHOTHER THROUGH EMAIL
  4- ENGINEERS PER CONTRACTOR GROUP
  4 TEAMS - 8 hr SHIFTS
  ONLY SENIOR ENGINEERS USED
  ATC-1 PROTOCOL FOR SEISMIC USED

EVALUATED STABILITY OF DEBRIS,
  OTHER BUILDINGS, ETC...
  TEMPORARY STRUCTURES.

SURVEYORS MONITORED SURROUNDING
  BUILDINGS EVERY 15 MINUTES TO
  IDENTIFY MOVEMENT AND POTENTIAL
  COLLAPSE.

ATC 20 - EVALUATED 400 BUILDINGS
  W/ MORE ENGINEERS
    ~1 hr / BUILDING.

MORE DETAILED EVALUATION AFTER
DATABASE OF PHOTOS

NY HAS OWN CODE-
  TRYING TO ADOPT IBC
  INSPECTION REQUIREMENTS
  ETC...