ASHRAE Standard 140-2020

Results Comparison
for
Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Results for TRNSYS 18.05.0001
(TRNSYS18)
vs.
Informative Annex B8, Section B8.2 Example Results

Prepared By
Thermal Energy System Specialists, LLC
(TESS)

Results Developed
15-Apr-2023

ASHRAE Standard 140-2020
Computer Programs, Program Authors, and Producers of Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

The programs used to generate the example results are described in Table B11-2. Under the computer program column, the first entry in each cell is the proper program name and version number. The entries in parentheses are the abbreviations for the programs generally used in the tables and charts which follow.

The second column ("Authoring Organization") indicates the national research facility, university, or industry organization with expertise in building science that wrote the simulation software.

The third column ("Implemented By") indicates the national research facility, university, or industry organization with expertise in building science that performed the simulations. The majority of organizations that performed simulations either ran software written by their organization or otherwise ran other building energy simulation software in addition to that written by their organization.

See Standard 140, Annex B11 for further details.

TABLE B11-2
Ground-Coupled Slab-On-Grade Analytical Verification
Participating Organizations and Models

Analytical Solution, Case GC10a	Authoring Organization	Implemented by
Delsante, Stokes, and Walsh (1983)	Commonwealth Scientific and Industrial Research Organisation, Australia	NREL/JNA, a,b United States
Verified Numerical Model		
FLUENT 6.0.20	Fluent, Incorporated, United States	PAAET,c Kuwait
MATLAB 7.0.4.365 (R14)	The MathWorks, Inc., United States	Dublin Institute of Technology, Ireland
TRNSYS 16.1	University of Wisconsin/TESS,d United States	TESS,d United States
Simulation Program		
BASECALC V1.0e	CETC,e Canada	CETC,e Canada
EnergyPlus 2.0.0.025	LBNL/UIUC/DOE-BT,f,g,h United States	GARD Analytics, Inc., United States
ESP-r/BASESIMP	CETC/ESRU,e,i Canada/United Kingdom	CETC,e Canada
GHT	NREL,a United States	NREL,a United States
SUNREL-GC 1.14.01	NREL,a United States	NREL,a United States
VA114 2.20/ISO-13370	VABI Software BV, The Netherlands; CEN/ISOj,k	VABI Software BV, The Netherlands

aNREL: National Renewable Energy Laboratory, United States

bJNA: J. Neymark & Associates, United States

cPAAET: Public Authority for Applied Education and Training, Kuwait

dTESS: Thermal Energy Systems Specialists, United States

eCETC: CANMET Energy Technology Centre, Natural Resources Canada, Canada

fLBNL: Lawrence Berkeley National Laboratory, United States

gUIUC: University of Illinois Urbana/Champaign, United States

hDOE-BT: U.S. Department of Energy, Office of Building Technologies, Energy Efficiency and Renewable Energy, United States

iESRU: Energy Systems Research Unit, University of Strathclyde, United Kingdom

jCEN: European Committee for Standardization, Belgium

kISO: International Organization for Standardization, Switzerland

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

List of Tables

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

List of Figures

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

List of Figures

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-1. "a"-Series Case Summary, Numerical Model Verification

	Analytical	Verified Numerical Models			Statistics				GHT/	
	Solution	TRNSYS	FLUENT	MATLAB			(Max-Min)	GHT	V.M.Meana	TRNSYS18
	CSIRO	TESS	PAAET	DIT	Min	Max	/Mean	NREL	-1	TESS
Floor Conduction										
GC10a (W or Wh/h)	**2433**	2427	2425	2432	2425	2432	0.3%	2415	-0.5%	
GC30a (W or Wh/h)		2642	2585	2695	2585	2695	4.2%	2457	-7.0%	
GC40a (kWh)		23033	22761	23609	22761	23609	3.7%	20812	-10.0%	
Phase Shift for Floor Conduction Peak (hours)										
GC40a		416	416	416	416	416	0.0%	487	17.1%	
GC10a Modeling Parameters										
E (depth, m)	infinite	40	40	300	40	300		30		
F (far-field, m)	infinite	40	40	150	40	150		20		
Time Simulated (Years)										
GC10a	s.s. soln.	8.0	s.s. model	s.s. model				6.0		
GC30a		7.0	s.s. model	s.s. model				6.0		
GC40a		6.0	5.0	10.0	5.0	10.0		6.0		

a "V.M.Mean" is average of verified numerical-model results.

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-2. Steady-State Conduction

	Verified Numerical Models				Statistics, Other Simulation Models									
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT	(Max-Min) /Mean	GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min)/ (V.M.Mean)a	TRNSYS18 TESS
Floor Conduction (W or Wh/h)														
GC30b	2533	2504	2570	2.6%	2341	2341	2652	2421			2341	2652	12.3%	2506
GC30c	2137	2123	2154	1.5%			2308	2092	1973	1973	1973	2308	15.7%	2542
GC60b	2113	2104	2128	1.1%		1999	2219	2069			1999	2219	10.4%	2278
GC65b	1994	1991	2004	0.7%		1895	1616	1920			1616	1920	15.3%	2125
Zone Heating Load (W or Wh/h)														
GC30b						2341	2652	2427			2341	2652	12.3%	2507
GC30c							2308	2098	2003	2003	2003	2308	14.3%	2543
GC60b						1999	2219	2075			1999	2219	10.4%	2279
GC65b						1895	1616	1925			1616	1925	15.5%	2126
(Zone Heating Load) - (Floor Conduction), [W or Wh/h]														
GC30b						0	0	6			0	6		1
GC30c							0	6	30	30	0	30		1
GC60b						0	0	6			0	6		1
GC65b						0	0	5			0	5		1

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

Table B8.2-3. Steady-State Supporting Information

	Verified Numerical Models				Statistics, All Results									
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT		GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min) /Mean	TRNSYS18 TESS
Zone Air Temperature (°C)														
GC30b						30.0	30.0	30.0			30.0	30.0	0.0%	30.0
GC30c							30.0	30.0	30.0	30.0	30.0	30.0	0.0%	30.0
GC60b						30.0	30.0	30.0			30.0	30.0	0.0%	30.0
GC65b						30.0	30.0	30.0			30.0	30.0	0.0%	30.0
Simulation Duration (Years)														
GC30b	6.0	s.s. model	s.s. model		5.0	5.0	7.0	1.0			0.0	7.0		5.0
GC30c	6.0	s.s. model	s.s. model				6.0	1.0	2.0	3.0	0.0	6.0		5.0
GC60b	6.0	s.s. model	s.s. model			5.0	7.0	1.0			0.0	7.0		5.0
GC65b	6.0	s.s. model	s.s. model			5.0	8.0	1.0			0.0	8.0		5.0

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-4. Steady-Periodic Last-Simulation-Year Conduction

	Verified Numerical Models				Statistics, Other Simulation Models									
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT	(Max-Min) /Mean	GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min)/ (V.M.Mean)a	TRNSYS18 TESS
Floor Conduction (kWh)														
GC40b	22099	21932	22513	2.6%	20513	20513	23204	21206			20513	23204	12.1%	21958
GC45b	32758	32456	33483	3.1%			33415	30856			30856	33415	7.8%	32491
GC50b	277923	277988	281418	1.3%			324257	289925			289925	324257	12.3%	277262
GC55b	35075	34879	35491	1.7%		33211	39932	31601			31601	39932	23.7%	35151
GC70b	17396	17434	17552	0.9%		16607	15553	16817			15553	16817	7.2%	18618
GC80b	6029	5939	6151	3.5%		5661	6059	5728			5661	6059	6.6%	6002
GC40c	18649	18598	18873	1.5%			20255	18330	17285	17285	17285	20255	15.9%	22272
GC45c	27004	26906	27392	1.8%			28707	26038	23849	23849	23849	28707	17.9%	33036
GC55c	20760	20714	20986	1.3%			22570	20172	20850	20850	20172	22570	11.5%	24843
GC80c	9192	9137	9314	1.9%			10073	8966	8635	8635	8635	10073	15.6%	10048
Zone Heating Load (kWh)														
GC40b	n/a	n/a				20513	23204	21260			20513	23204	12.1%	21967
GC45b	n/a	n/a					33415	30924			30924	33415	7.6%	32502
GC50b	n/a	n/a					324257	291502			291502	324257	11.7%	277498
GC55b	n/a	n/a				33211	39932	31654			31654	39932	23.6%	35160
GC70b	n/a	n/a				16607	15553	16865			15553	16865	7.5%	18627
GC80b	n/a	n/a				5661	6059	5778			5661	6059	6.6%	6011
GC40c	n/a	n/a					20255	18379	17545	17545	17545	20255	14.5%	22281
GC45c	n/a	n/a					28707	26101	24185	24185	24185	28707	16.7%	33048
GC55c	n/a	n/a					22570	20221	21111	21111	20221	22570	11.3%	24852
GC80c	n/a	n/a					10073	9013	8848	8848	8848	10073	13.3%	10056
(Zone Heating Load) - (Floor Conduction) [kWh]														
GC40b						0	0	54			0	54		9
GC45b							0	68			0	68		12
GC50b							0	1577			0	1577		236
GC55b						0	0	53			0	53		9
GC70b						0	0	48			0	48		9
GC80b						0	0	50			0	50		9
GC40c							0	49	260	260	0	260		9
GC45c							0	63	336	336	0	336		12
GC55c							0	49	261	261	0	261		9
GC80c							0	47	213	213	0	213		9

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-5. Steady-Periodic Last-Simulation-Year Peak-Hour Conduction

Verified Numerical-Model Results										
	TRNSYS			FLUENT			MATLAB			(Max-Min)
	TESS	Date	Hour	PAAET	Date	Hour	DIT	Date	Hour	/Mean
Floor Conduction (W or Wh/h)										
GC40a	3087	1-Feb	12	3042	1-Feb	12	3174	1-Feb	12	4.2%
GC40b	2941	1-Feb	13	2914	3-Feb	13	3002	2-Feb	13	3.0%
GC45b	4444	1-Feb	13	4396	2-Feb	13	4551	2-Feb	13	3.5%
GC50b	34531	4-Feb	13	34510	3-Feb	13	35033	3-Feb	13	1.5%
GC55b	4366	22-Jan	13	4336	21-Jan	13	4427	21-Jan	13	2.1%
GC70b	2254	11-Feb	16	2259	11-Feb	15	2276	11-Feb	16	1.0%
GC80b	776	7-Feb	20	763	8-Feb	19	794	7-Feb	19	4.0%
GC40c	2454	7-Feb	14	2444	7-Feb	14	2487	6-Feb	14	1.7%
GC45c	3634	4-Feb	14	3618	6-Feb	14	3691	6-Feb	14	2.0%
GC55c	2710	4-Feb	14	2703	6-Feb	14	2744	6-Feb	14	1.5%
GC80c	1190	9-Feb	17	1181	9-Feb	17	1207	8-Feb	17	2.2%

Other Simulation Results																			Statistics, Other Sim. Models					
	GHT			SUNREL-GC			EnergyPlus			VA114/ISO-13370			ESP-r/BASESIMP			BASECALC						TRNSYS18		
	NREL	Date	Hour	NREL	Date	Hour	GARD	Date	Hour	VABI	Date	Hour	NRCan	Date	Hour	NRCan	Date	Hour	Min	Max	(Max-Min)/ (V.M.Mean)a	TESS	Date	Hour
Floor Conduction (W or Wh/h)																								
GC40a	2758	4-Feb	11																					
GC40b	2710	4-Feb	13	2710	4-Feb	13	3005	02/02	03:00	2899	21-Feb	2							2710	3005	10.0%	2922	1-Feb	14
GC45b							4415	02/02	04:00	4318	20-Feb	20							4318	4415	2.2%	4409	1-Feb	14
GC50b							39570	01/01	01:00	36304	20-Feb	7							36304	39570	9.4%	34452	4-Feb	14
GC55b				4102	22-Jan	14	4860	01/01	01:00	4085	20-Feb	24							4085	4860	17.7%	4376	22-Jan	14
GC70b				2144	11-Feb	18	1906	02/03	08:00	2252	24-Feb	2							1906	2252	15.3%	2431	9-Feb	16
GC80b				722	9-Feb	22	766	02/04	02:00	753	5-Mar	2							722	766	5.6%	772	7-Feb	20
GC40c							2650	02/03	11:00	2472	24-Feb	5	2231	31-Jan	8	2224	Feb	0	2224	2650	17.3%	2543	1-Jan	1
GC45c							3827	02/03	07:00	3606	25-Feb	1	3192	31-Jan	6	3178	Jan	0	3178	3827	17.8%	3772	1-Jan	1
GC55c							2926	02/03	11:00	2682	24-Feb	22	2666	29-Jan	23	2659	Jan	0	2659	2926	9.8%	2836	1-Jan	1
GC80c							1300	02/05	05:00	1187	1-Mar	24	1094	2-Feb	5	1091	Feb	0	1091	1300	17.5%	1148	1-Jan	1
	GHT			SUNREL-GC			EnergyPlus			VA114/ISO-13370			ESP-r/BASESIMP			BASECALC					(Max-Min)	TRNSYS18		
	NREL	Date	Hour	NREL	Date	Hour	GARD	Date	Hour	VABI	Date	Hour	NRCan	Date	Hour	NRCan	Date	Hour	Min	Max	/Mean	TESS	Date	Hour
Zone Heating Load (W or Wh/h)																								
GC40b				2710	4-Feb	13	3005	02/02	03:00	2907	22-Feb	4							2710	3005	10.3%	2923	1-Feb	14
GC45b							4415	02/02	04:00	4328	22-Feb	4							4328	4415	2.0%	4411	1-Feb	14
GC50b							39570	01/01	01:00	36021	21-Feb	3							36021	39570	9.4%	34484	4-Feb	13
GC55b				4102	22-Jan	14	4860	01/01	01:00	4093	22-Feb	3							4093	4860	17.6%	4377	22-Jan	14
GC70b				2144	11-Feb	18	1906	02/03	08:00	2259	27-Feb	3							1906	2259	16.8%	2432	9-Feb	16
GC80b				722	9-Feb	22	766	02/04	02:00	760	8-Mar	4							722	766	5.8%	773	7-Feb	22
GC40c							2650	02/03	11:00	2479	26-Feb	3	2273	1-Feb	20.0	2261	Feb	0	2261	2650	16.1%	2545	1-Jan	4
GC45c							3827	02/03	07:00	3616	26-Feb	3	3246	31-Jan	4.0	3228	Jan	0	3228	3827	17.2%	3774	1-Jan	4
GC55c							2926	02/03	11:00	2690	25-Feb	4	2708	28-Jan	4.0	2698	Jan	0	2690	2926	8.6%	2838	1-Jan	4
GC80c							1300	02/05	05:00	1194	4-Mar	3	1128	31-Jan	4.0	1122	Feb	0	1122	1300	15.0%	1149	1-Jan	4
(Zone Heating Load) - (Floor Conduction), [W or Wh/h, may not be for same hour]																								
GC40b				0			0			8									0	8		1		
GC45b							0			10									0	10		2		
GC50b							0			-283									-283	0		33		
GC55b				0			0			8									0	8		1		
GC70b				0			0			7									0	7		1		
GC80b				0			0			7									0	7		1		
GC40c							0			7			42			37			0	42		1		
GC45c							0			10			54			50			0	54		2		
GC55c							0			8			42			39			0	42		1		
GC80c							0			7			34			31			0	34		1		

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-6. Time from Coldest Hour (Jan 15, Hour 4) to Peak Conduction Occurrence

	Verified Numerical Models				Statistics, Other Simulation Models									
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT	(Max-Min) /Mean	GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min)/ (V.M.Mean)a	TRNSYS18 TESS
Phase Shift for Floor Conduction Peak (hours)														
GC40b	417	465	441	10.9%	489	489		886			489	886	90.0%	418
GC45b	417	441	441	5.5%				880			880	880	0.0%	418
GC50b	489	465	465	5.1%				867			867	867	0.0%	490
GC55b	177	153	153	14.9%		178		884			178	884	438.5%	178
GC70b	660	659	660	0.2%		662		958			662	958	44.9%	612
GC80b	568	591	567	4.2%		618		1174			618	1174	96.6%	568
GC40c	562	562	538	4.3%				961	388		388	961	103.4%	-339
GC45c	490	538	538	9.2%				981	386		386	981	114.0%	-339
GC55c	490	538	538	9.2%				978	355		355	978	119.3%	-339
GC80c	613	613	589	4.0%				1100	433		433	1100	110.2%	-339
Phase Shift for Zone Load Peak (hours)														
GC40b						489		912			489	912	95.9%	418
GC45b								912			912	912	0.0%	418
GC50b								887			887	887	0.0%	489
GC55b						178		911			178	911	455.3%	178
GC70b						662		1031			662	1031	55.9%	612
GC80b						618		1248			618	1248	109.5%	570
GC40c								1007	424		424	1007	105.2%	-336
GC45c								1007	384		384	1007	119.3%	-336
GC55c								984	312		312	984	128.7%	-336
GC80c								1151	384		384	1151	126.8%	-336

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-7. Steady-Periodic Supporting Information

	Verified Numerical Models										Statistics, All Results			
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT		GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min) /Mean	TRNSYS18 TESS
Mean Annual Zone Air Temperature (°C)														
GC40b						30.0	30.0	30.0			30.0	30.0	0.0%	30.0
GC45b							30.0	30.0			30.0	30.0	0.0%	30.0
GC50b							30.0	30.0			30.0	30.0	0.0%	30.0
GC55b						30.0	30.0	30.0			30.0	30.0	0.0%	30.0
GC70b						30.0	30.0	30.0			30.0	30.0	0.0%	30.0
GC80b						30.0	30.0	30.0			30.0	30.0	0.0%	30.0
GC40c							30.0	30.0	30.0	30.0	30.0	30.0	0.0%	30.0
GC45c							30.0	30.0	30.0	30.0	30.0	30.0	0.0%	30.0
GC55c							30.0	30.0	30.0	30.0	30.0	30.0	0.0%	30.0
GC80c							30.0	30.0	30.0	30.0	30.0	30.0	0.0%	30.0
Simulation Duration (Years)														
GC40b	5.0	6.0	10.0		5.0	5.0	7.0	1.0			1.0	10.0		5.0
GC45b	5.0	3.0	10.0				7.0	1.0			1.0	10.0		4.0
GC50b	8.0	8.0	10.0				8.0	1.0			1.0	10.0		8.0
GC55b	3.0	3.0	10.0			2.0	3.0	1.0			1.0	10.0		2.0
GC70b	6.0	3.0	10.0			5.0	7.0	1.0			1.0	10.0		5.0
GC80b	10.0	3.0	10.0			5.0	16.0	1.0			1.0	16.0		5.0
GC40c	5.0	3.0	10.0				6.0	1.0	2.0	3.0	1.0	10.0		5.0
GC45c	5.0	3.0	10.0				6.0	1.0	2.0	3.0	1.0	10.0		5.0
GC55c	3.0	3.0	10.0				3.0	1.0	2.0	3.0	1.0	10.0		2.0
GC80c	8.0	4.0	10.0				10.0	1.0	2.0	3.0	1.0	10.0		8.0

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-8. Steady-Periodic Minimum ODB and Time of Occurrence

Verified Numerical-Model Results

	TRNSYS			# hours at	FLUENT			# hours at	MATLAB			# hours at
	TESS	Date	Hour	ODBmin	PAAET	Date	Hour	ODBmin	DIT	Date	Hour	ODBmin
Outdoor Dry-Bulb Temperature (°C)												
GC40a	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC40b	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC45b	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC50b	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC55b	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC70b	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC80b	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC40c	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC45c	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC55c	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0
GC80c	2.1	8-Jan	4.0	30.0					2.0	8-Jan	4.0	15.0

Other Simulation Results

	GHT			# hours at	SUNREL-GC			# hours at	EnergyPlus			# hours at	VA114/ISO-13370			# hours at	ESP-r/BASESIMP			# hours at	BASECALC			# hours at	TRNSYS18			# hours at
	NREL	Date	Hour	ODBmin	NREL	Date	Hour	ODBmin	GARD	Date	Hour	ODBmin	VABI	Date	Hour	ODBmin	NRCan	Date	Hour	ODBmin	NRCan	Date	Hour	ODBmin	TESS	Date	Hour	ODBmin
Outdoor Dry-Bulb Temperature (°C)																												
GC40a	2.0	8-Jan	4.0	15.0																								
GC40b	2.0	8-Jan	4.0	15.0	2.0	8-Jan	4.0	15.0	2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0									2.1	8-Jan	4.0	30.0
GC45b									2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0									2.1	8-Jan	4.0	30.0
GC50b									2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0									2.1	8-Jan	4.0	30.0
GC55b					2.0	8-Jan	4.0	15.0	2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0									2.1	8-Jan	4.0	30.0
GC70b					2.0	8-Jan	4.0	15.0	2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0									2.1	8-Jan	4.0	30.0
GC80b					2.0	8-Jan	4.0	15.0	2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0									2.1	8-Jan	4.0	30.0
GC40c									2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0	2.0	8-Jan	4.0	15.0	4.0	Jan	0.0	744.0	2.1	8-Jan	4.0	30.0
GC45c									2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0	2.0	8-Jan	4.0	15.0	4.0	Jan	0.0	744.0	2.1	8-Jan	4.0	30.0
GC55c									2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0	2.0	8-Jan	4.0	15.0	4.0	Jan	0.0	744.0	2.1	8-Jan	4.0	30.0
GC80c									2.0	01/08	04:00	15.0	2.0	8-Jan	4.0	16.0	2.0	8-Jan	4.0	15.0	4.0	Jan	0.0	744.0	2.1	8-Jan	4.0	30.0

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-9. Delta Steady-State Conduction

	Verified Numerical Models				Other Simulation Models						Statistics, Other Simulation Models			
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT	(Max-Min) /Mean	GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min)/ (V.M.Mean)a	TRNSYS18 TESS
Floor Conduction (W or Wh/h)														
GC30a-GC10a	214	160	263	48.5%	42						42	42	0.0%	
GC40ab-GC30a	-12.4	13.2	0.1	8227.4%	-80.9						-80.9	-80.9	0.0%	
GC40bb-GC30b	-10.3	-0.1	0.0	-297.9%	0.5	0.5	-3.6	-0.2			-3.6	0.5	-117.7%	0.7
GC40cb-GC30c	-7.9	0.2	0.0	-314.3%			4.3	0.5	0.2	0.2	0.2	4.3	-160.0%	0.8
GC30a-GC30b	109	81	125	41.7%	116						116	116	0.0%	
GC30a-GC30c	505	462	541	15.6%										
GC30b-GC60b	420	400	442	10.0%		342	434	352			342	434	21.8%	228
GC60b-GC65b	120	114	125	9.3%		104	603	149			104	603	418.5%	153
GC30b-GC65b	539	513	566	9.9%		446	1037	501			446	1037	109.5%	381
GC70bb-GC65b	-7.9	-0.4	0.0	-284.9%		0.5	160.0	-0.3			-0.3	160.0	-5797.5%	0.5
Zone Load (W or Wh/h)														
GC40bb-GC30b						0.5	-3.6	-0.1			-3.6	0.5	-117.7%	0.7
GC40cb-GC30c							4.3	0.1	-0.1	-0.1	-0.1	4.3	-172.4%	0.8
GC30b-GC60b						342	434	352			342	434	21.8%	228
GC60b-GC65b						104	603	150			104	603	418.5%	153
GC30b-GC65b						446	1037	502			446	1037	109.5%	381
GC70bb-GC65b						0.5	160.0	0.2			0.2	160.0	-5780.2%	0.5

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

b Values for GC40a, GC40b, GC40c and GC70b are: annual total × 1000 (W/kW) / 8760 (h/y)

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-10. Delta Steady-Periodic Annual Total Conduction

	Verified Numerical Models										Statistics, Other Simulation Models			
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT	(Max-Min) /Mean	GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min)/ (V.M.Mean)a	TRNSYS18 TESS
Floor Conduction (kWh)														
GC40a-GC40b	933	829	1096	28.1%	299						299	299	0.0%	
GC45b-GC40b	10659	10524	10971	4.2%			10211	9650			9650	10211	5.2%	10533
GC40b-GC50bc	15846	15677	16181	3.2%			15908	14683			14683	15908	7.7%	15720
GC55b-GC40b	12976	12947	12978	0.2%		12698	16728	10395			10395	16728	48.8%	13193
GC40b-GC70b	4704	4498	4961	9.8%		3906	7650	4389			3906	7650	79.3%	3340
GC40b-GC80b	16071	15993	16362	2.3%		14852	17145	15478			14852	17145	14.2%	15956
GC45c-GC40c	8355	8309	8519	2.5%			8452	7708	6564	6564	6564	8452	22.5%	10764
GC55c-GC40c	2111	2117	2113	0.3%			2315	1842	3565	3565	1842	3565	81.5%	2572
GC40c-GC80c	9457	9461	9559	1.1%			10182	9364	8650	8650	8650	10182	16.1%	12224
Zone Conduction (kWh)														
GC45b-GC40b							10211	9664			9664	10211	5.1%	10536
GC40b-GC50bc							15908	14701			14701	15908	7.6%	15723
GC55b-GC40b						12698	16728	10394			10394	16728	48.8%	13193
GC40b-GC70b						3906	7650	4395			3906	7650	79.3%	3340
GC40b-GC80b						14852	17145	15482			14852	17145	14.2%	15956
GC45c-GC40c							8452	7722	6640	6640	6640	8452	21.6%	10767
GC55c-GC40c							2315	1842	3566	3566	1842	3566	81.6%	2572
GC40c-GC80c							10182	9366	8697	8697	8697	10182	15.6%	12224

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

c GC50b with normalized floor area: GC50b / (80 x 80) x (12 x 12)

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-11. Delta Steady-Periodic Last-Year Peak Hour Floor Conduction

	Verified Numerical Models										Statistics, Other Simulation Models			
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT	(Max-Min) /Mean	GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min)/ (V.M.Mean)a	TRNSYS18 TESS
Floor Conduction (W or Wh/h)														
GC40a-GC40b	145	128	171	29.1%	48						48	48	0.0%	
GC45b-GC40b	1503	1482	1549	4.4%			1410	1419			1410	1419	0.6%	1487
GC40b-GC50bc	2164	2138	2214	3.5%			2115	2082			2082	2115	1.5%	2147
GC55b-GC40b	1425	1422	1425	0.2%		1391	1855	1186			1186	1855	47.0%	1454
GC40b-GC70b	687	655	726	10.2%		566	1099	647			566	1099	77.3%	491
GC40b-GC80b	2166	2151	2208	2.6%		1988	2239	2146			1988	2239	11.5%	2150
GC45c-GC40c	1180	1173	1205	2.7%			1176	1134	961	954	954	1176	18.7%	1229
GC55c-GC40c	256	258	258	0.9%			275	210	435	435	210	435	87.4%	293
GC40c-GC80c	1265	1264	1279	1.2%			1351	1285	1137	1133	1133	1351	17.1%	1396
Zone Conduction (W or Wh/h)														
GC45b-GC40b							1410	1421			1410	1421	0.7%	1488
GC40b-GC50bc							2115	2097			2097	2115	0.8%	2147
GC55b-GC40b						1391	1855	1186			1186	1855	47.0%	1454
GC40b-GC70b						566	1099	648			566	1099	77.3%	491
GC40b-GC80b						1988	2239	2147			1988	2239	11.5%	2150
GC45c-GC40c							1176	1137	973	967	967	1176	17.6%	1229
GC55c-GC40c							275	211	435	437	211	437	87.8%	293
GC40c-GC80c							1351	1285	1145	1139	1139	1351	16.7%	1396

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

c GC50b with normalized floor area: GC50b / (80 x 80) x (12 x 12)

ASHRAE Standard 140-2020, Informative Annex B8, Section B8.2
Example Results for Section 5.2.4 - Ground Coupled Slab-On-Grade Analytical Verification Tests

Note: The statistics in the tables below are based on the Standard 140 informative example results.
These statistics do not have any substantial importance and are not to be interpreted as acceptance criteria.

Table B8.2-12. Delta Steady-Periodic Conduction v Coldest Hour Phase Shift

	Verified Numerical Models				Other Simulation Models						Statistics, Other Simulation Models			
	TRNSYS TESS	FLUENT PAAET	MATLAB DIT	(Max-Min) /Mean	GHT NREL	SUNREL-GC NREL	EnergyPlus GARD	VA114/ ISO-13370 VABI	ESP-r/ BASESIMP NRCan	BASECALC NRCan	Min	Max	(Max-Min)/ (V.M.Mean)a	TRNSYS18 TESS
Floor (Hours)														
GC40a-GC40b	-1	-49	-25	-192.0%	-2						-2	-2	0.0%	
GC45b-GC40b	0	-24	0	-300.0%				-6			-6	-6	0.0%	0
GC40b-GC50bc	-72	0	-24	-225.0%				19			19	19	0.0%	-72
GC55b-GC40b	-240	-312	-288	-25.7%		-311		-2			-311	-2	-110.4%	-240
GC40b-GC70b	-243	-194	-219	-22.4%		-173		-72			-173	-72	-46.2%	-194
GC40b-GC80b	-151	-126	-126	-18.6%		-129		-288			-288	-129	-118.4%	-150
GC45c-GC40c	-72	-24	0	-225.0%				20	-2		-2	20	-68.8%	0
GC55c-GC40c	-72	-24	0	-225.0%				17	-33		-33	17	-156.3%	0
GC40c-GC80c	-51	-51	-51	0.0%				-139	-45		-139	-45	-184.3%	0
Zone (Hours)														
GC45b-GC40b								0			0	0	0.0%	0
GC40b-GC50bc								25			25	25	0.0%	-71
GC55b-GC40b						-311		-1			-311	-1	-110.7%	-240
GC40b-GC70b						-173		-119			-173	-119	-24.7%	-194
GC40b-GC80b						-129		-336			-336	-129	-154.1%	-152
GC45c-GC40c								0	-40		-40	0	-125.0%	0
GC55c-GC40c								-23	-112		-112	-23	-278.1%	0
GC40c-GC80c								-144	40		-144	40	-360.8%	0

a "V.M.Mean" is average of verified numerical-model results; for zone load results the average of the floor conduction results is used.

c GC50b with normalized floor area: GC50b / (80 x 80) x (12 x 12)

Figure B8.2-1. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-State Floor Conduction

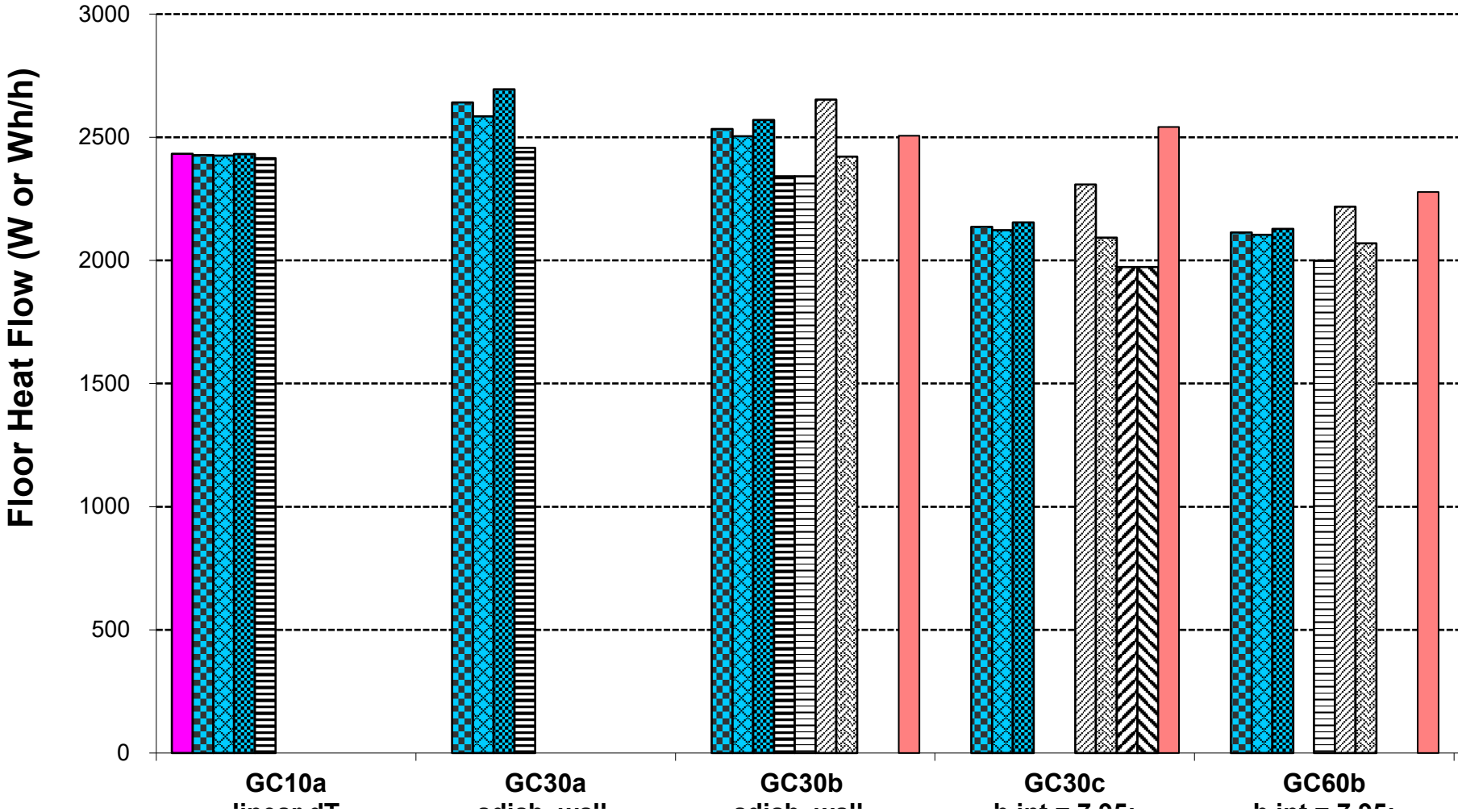

Figure B8.2-2. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-State Floor Conduction Sensitivity

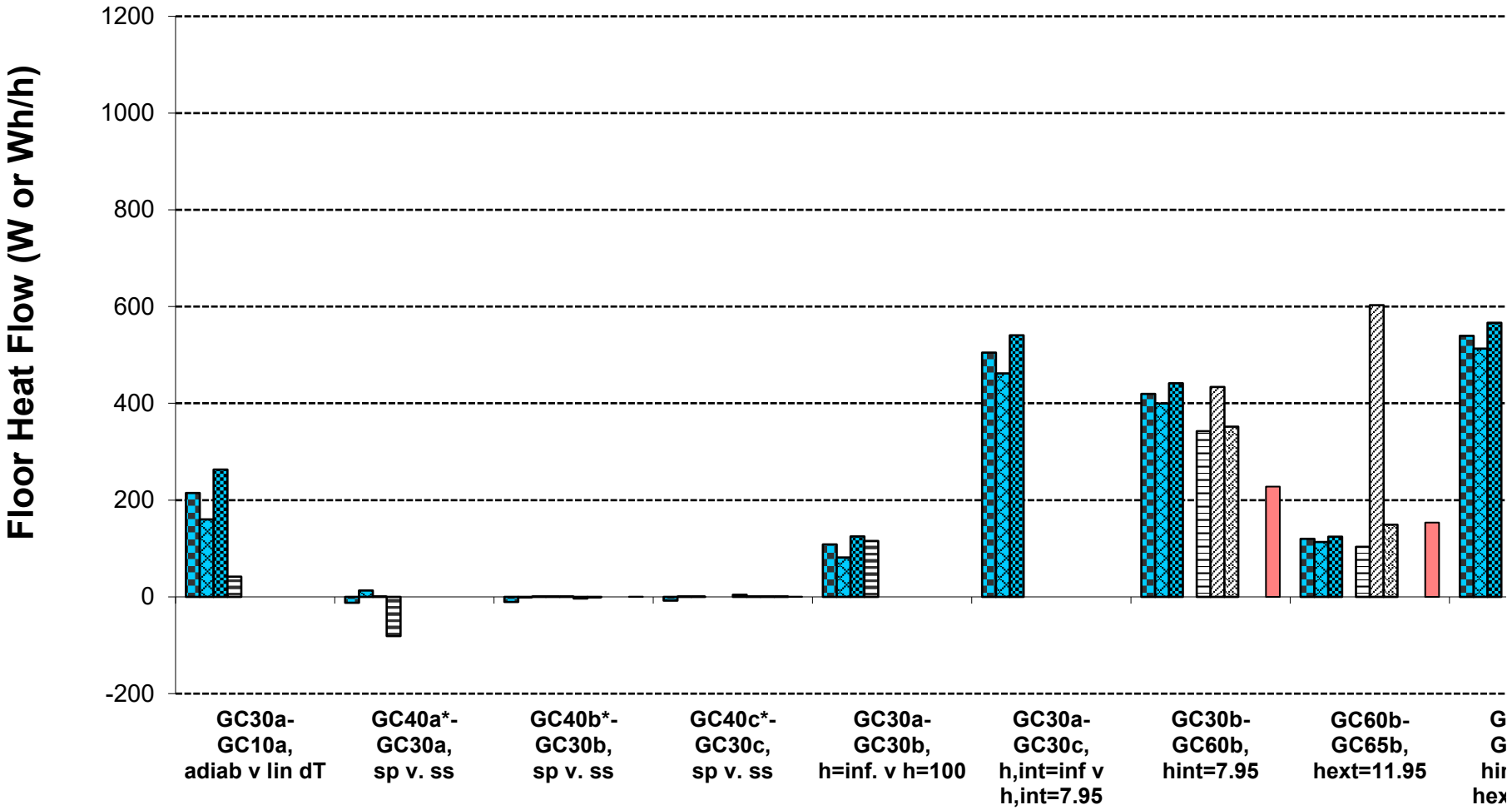

Figure B8.2-3. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-State Zone Heating Load

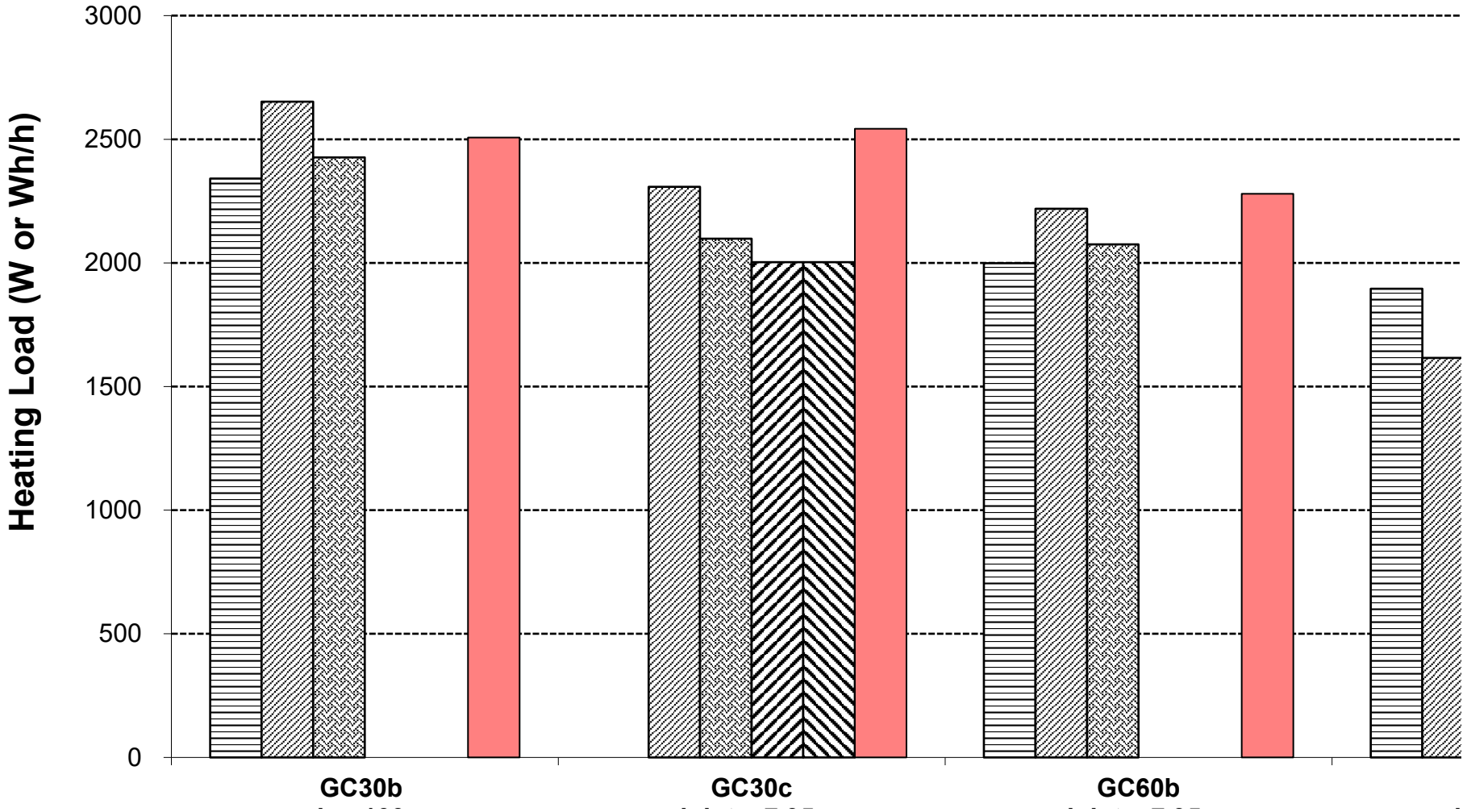

Figure B8.2-4. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-State Zone Heating Load Sensitivity

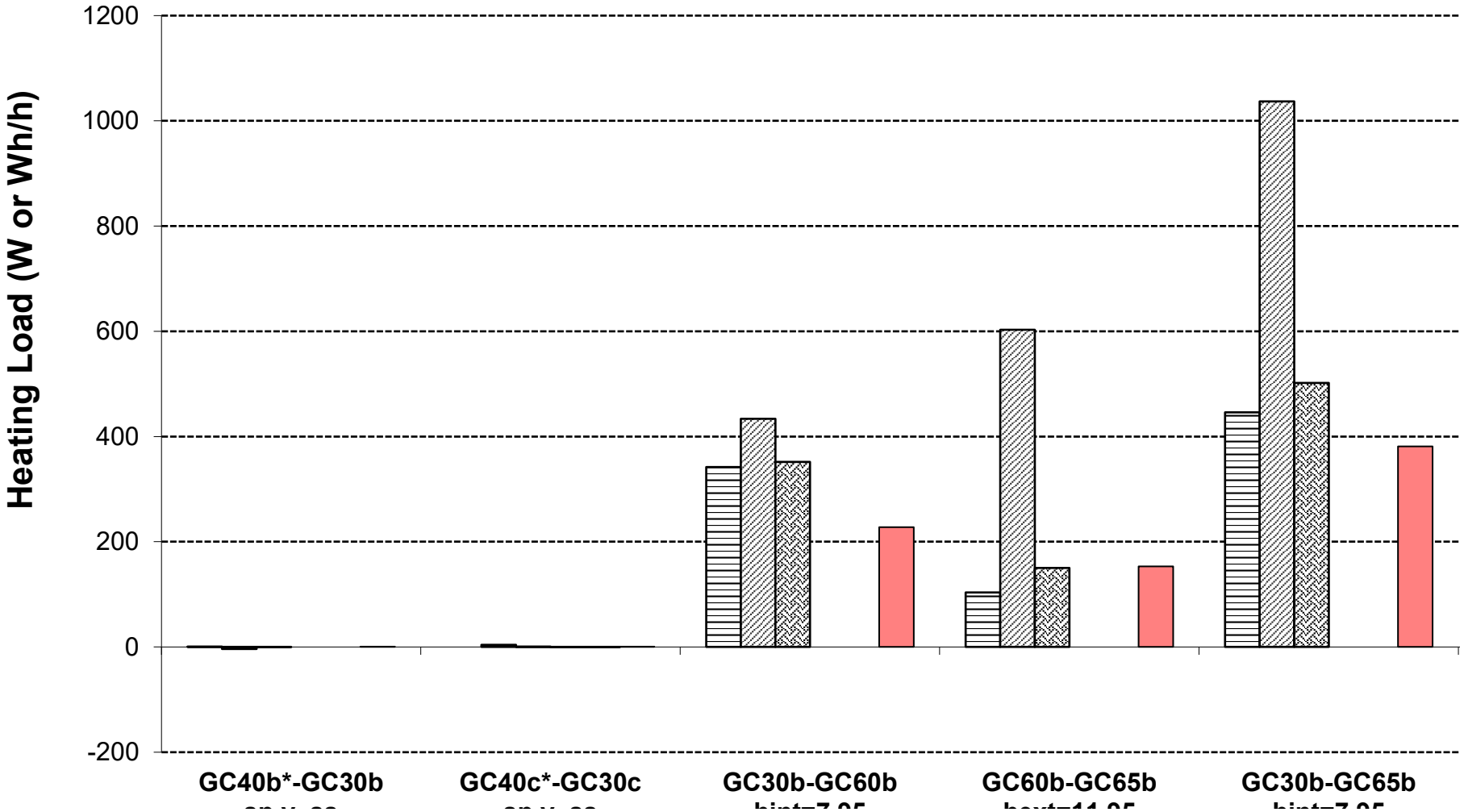

Figure B8.2-5. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-State (Zone Heating Load) - (Floor Conduction)

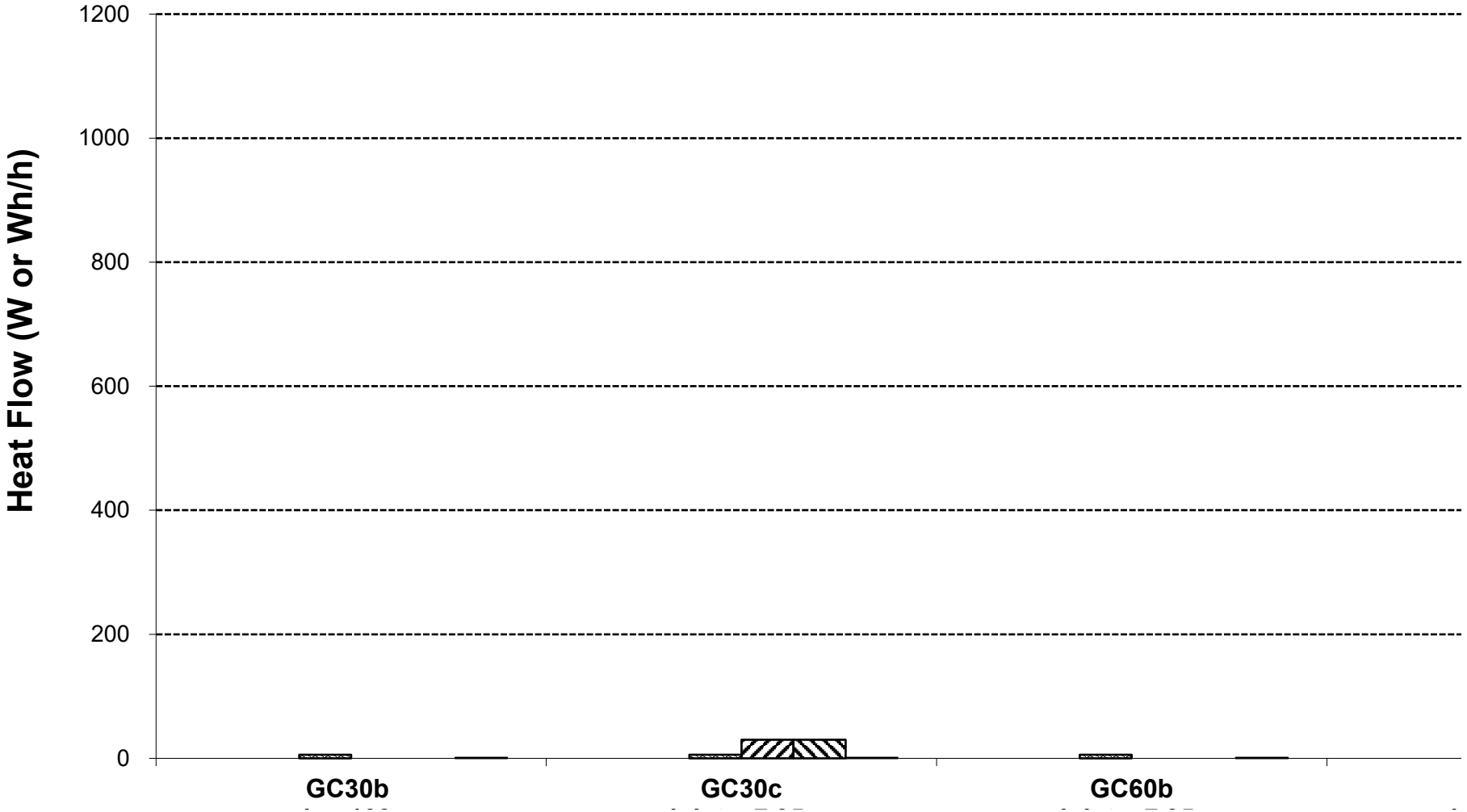

Figure B8.2-6. IEA BESTEST Ground Coupling: In-Depth Floor Slab Case GC10a Modeling Parameters

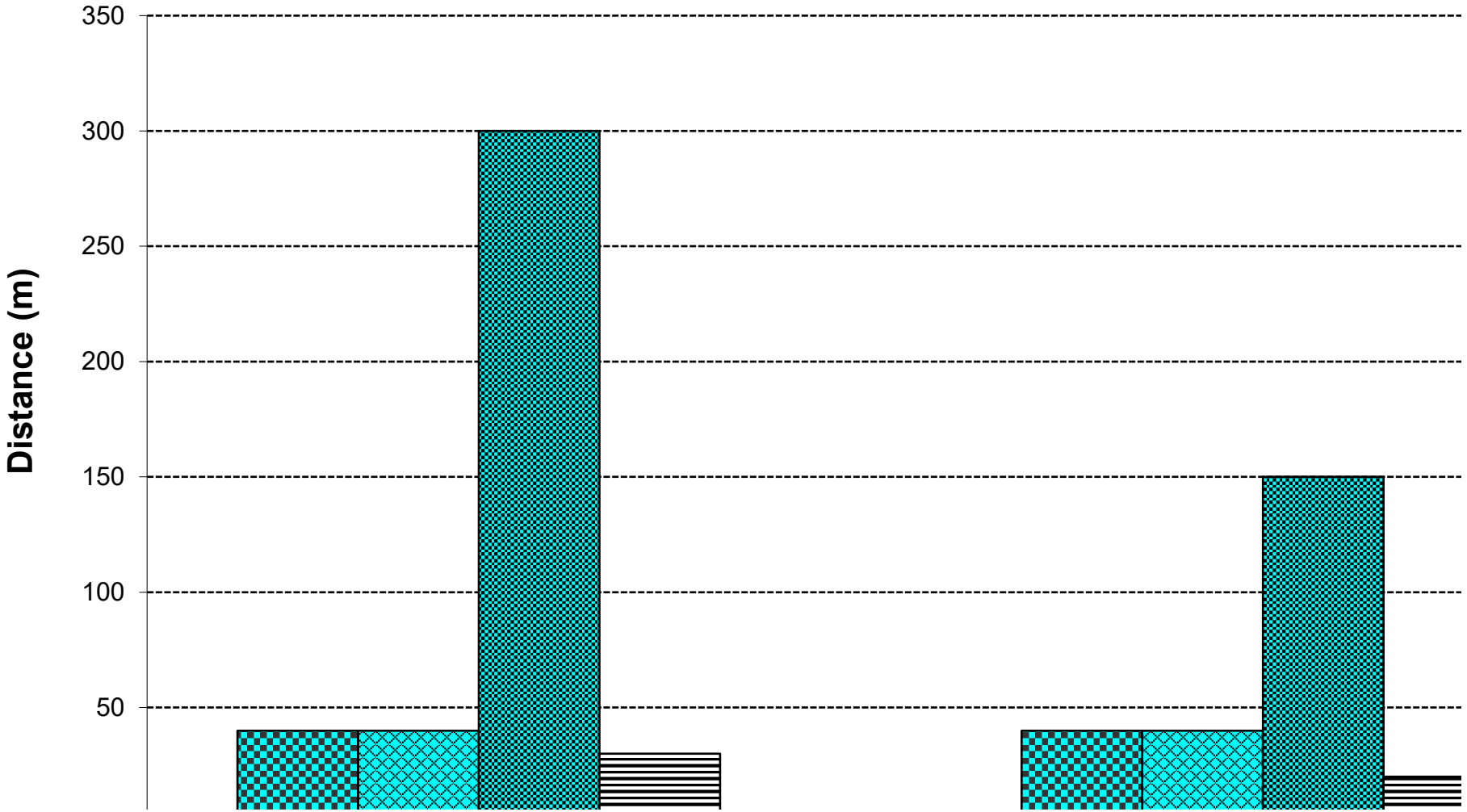

Figure B8.2-7. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-State Zone Temperature

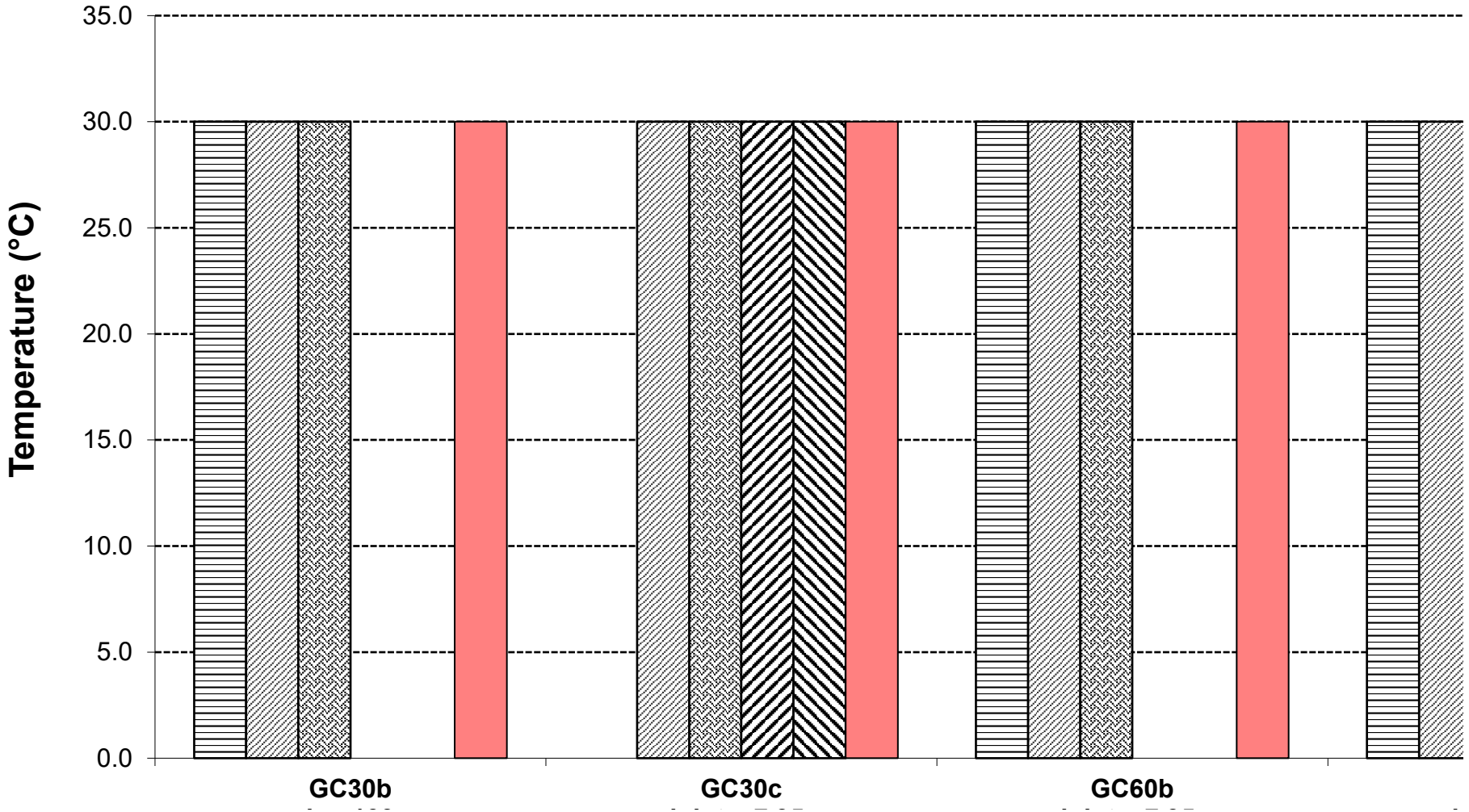

Figure B8.2-8.
IEA BESTEST Ground Coupling: In-Depth Floor Slab, GC10a
Steady-State Surface Temperatures (Y=0, thru edge center)

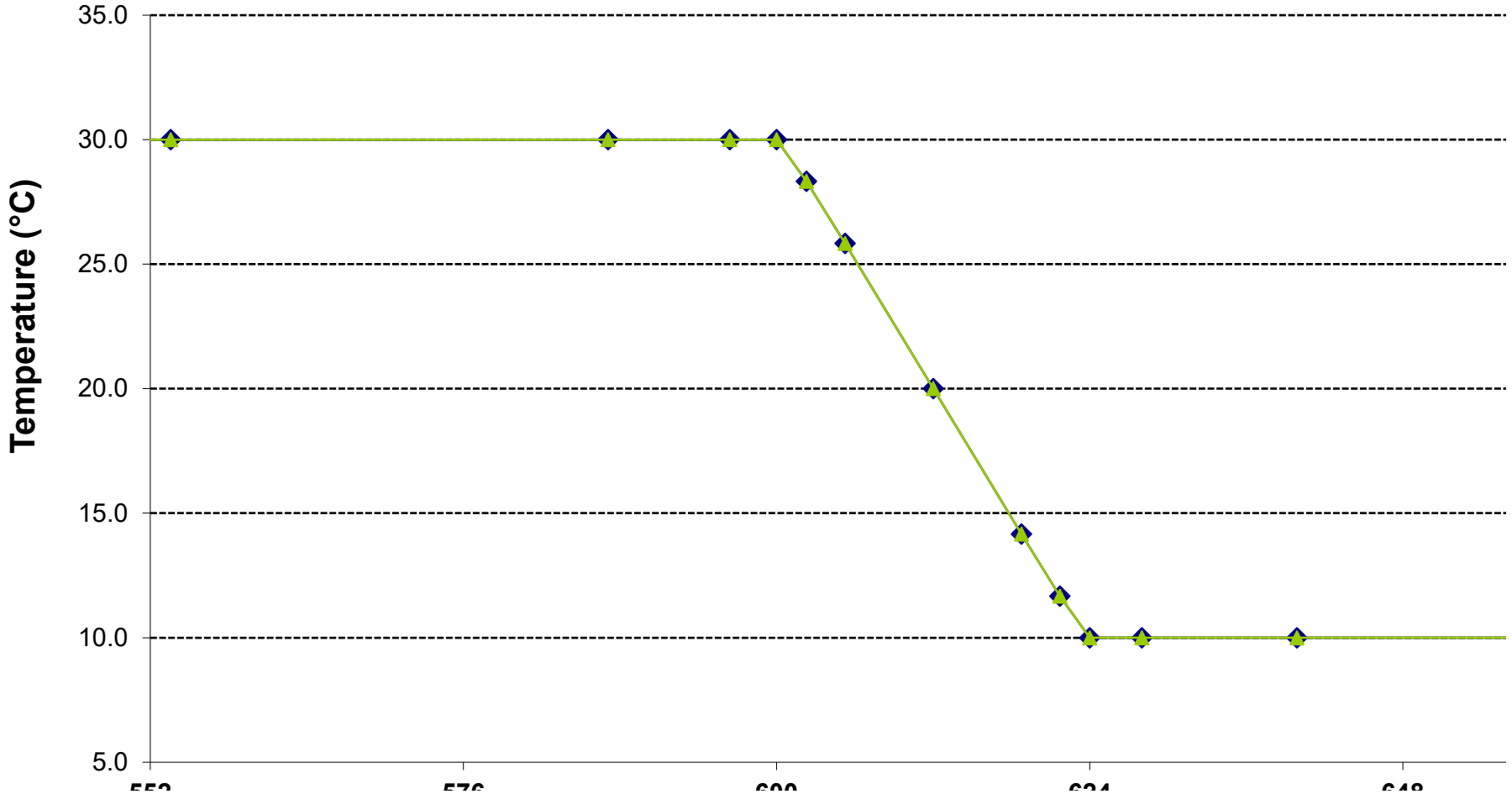

Figure B8.2-9.
IEA BESTEST Ground Coupling: In-Depth Floor Slab, GC10a
Steady-State Surface Temperatures (Y=X, thru corner)

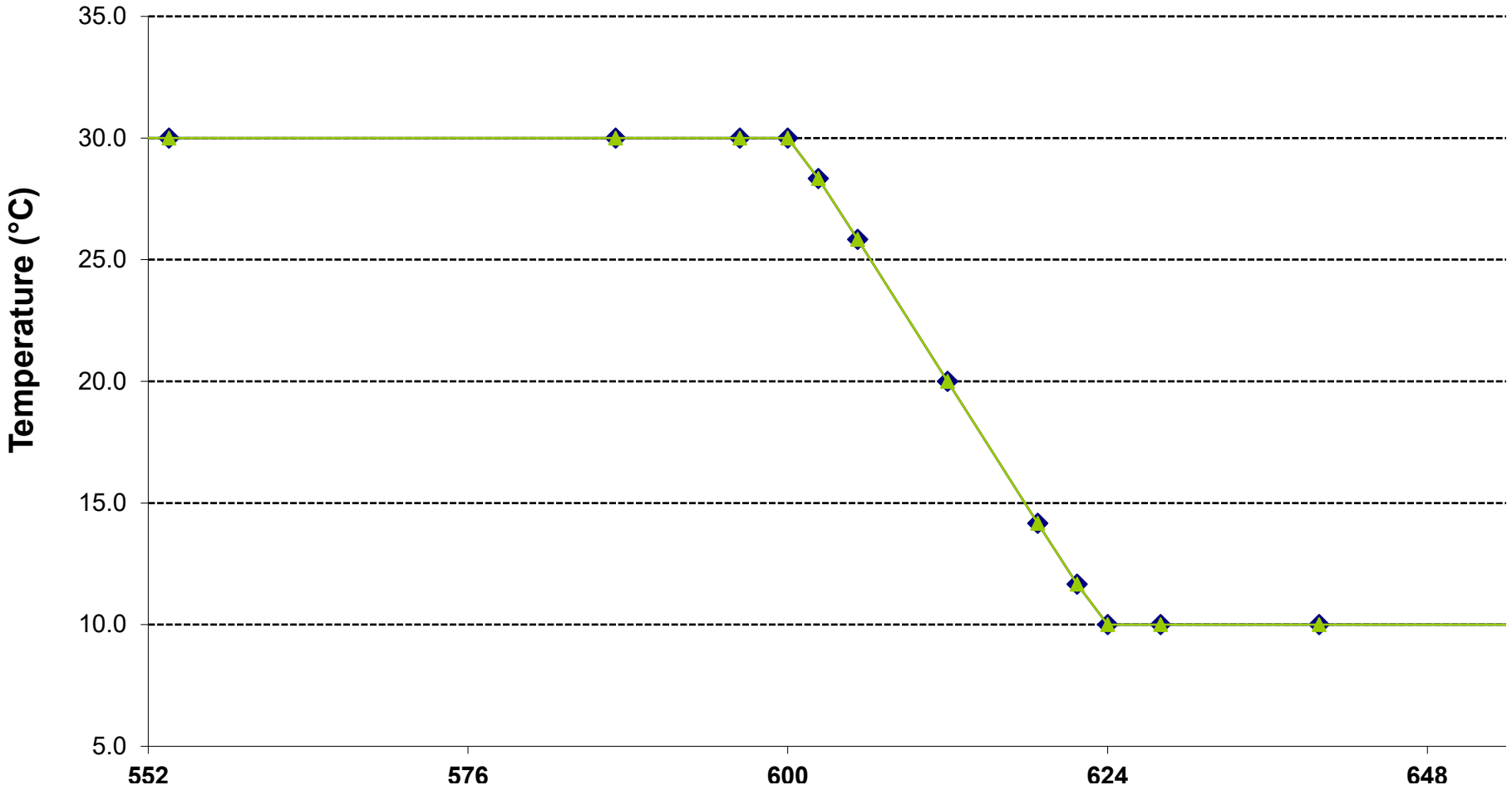

Figure B8.2-10.
IEA BESTEST Ground Coupling: In-Depth Floor Slab, GC10a, GC30a
Steady-State Near-Surface Temperatures (Y=0, thru center of edge)

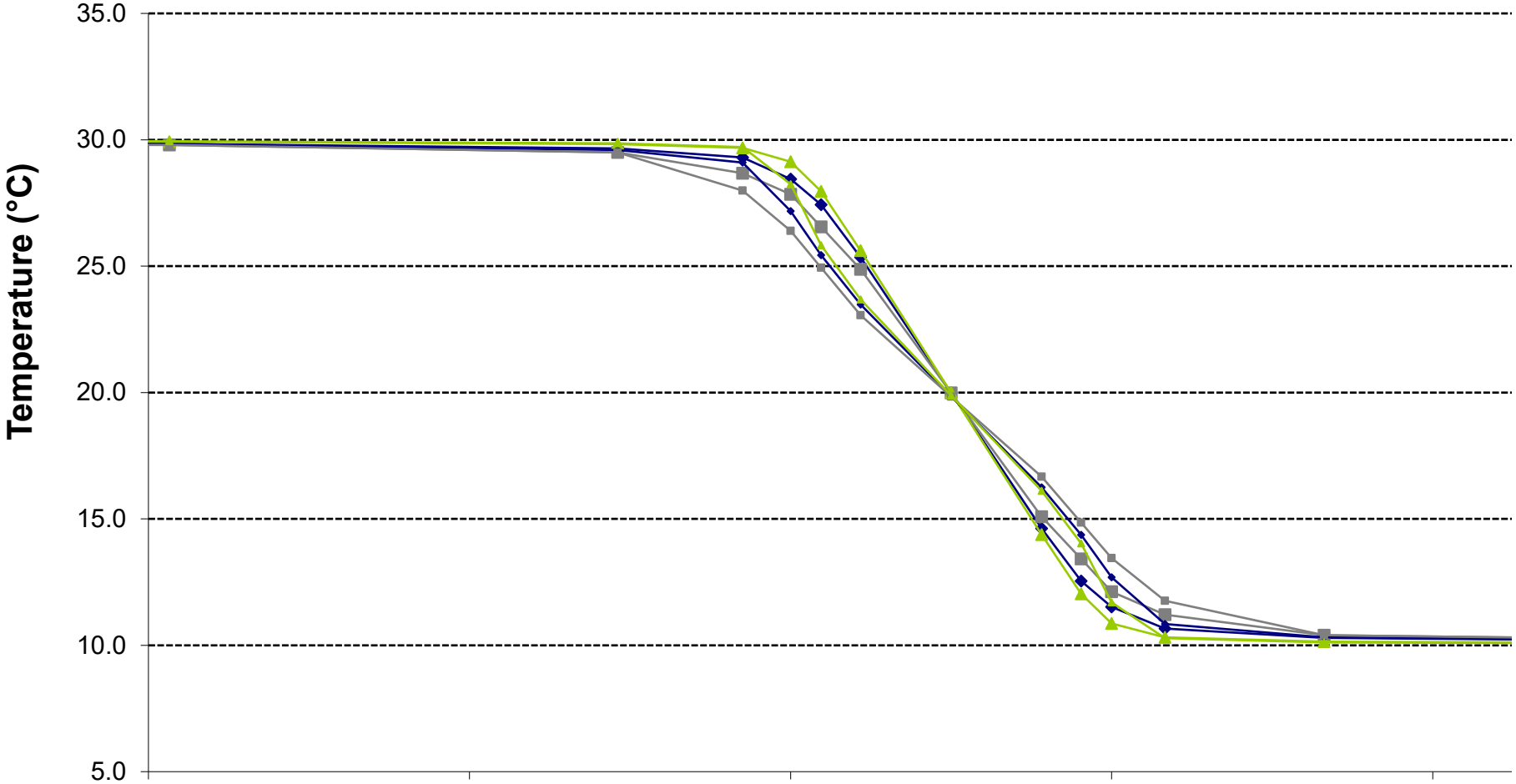

Figure B8.2-11.
IEA BESTEST Ground Coupling: In-Depth Floor Slab, GC10a, GC30a
Steady-State Near-Surface Temperatures (Y=X, thru corner)

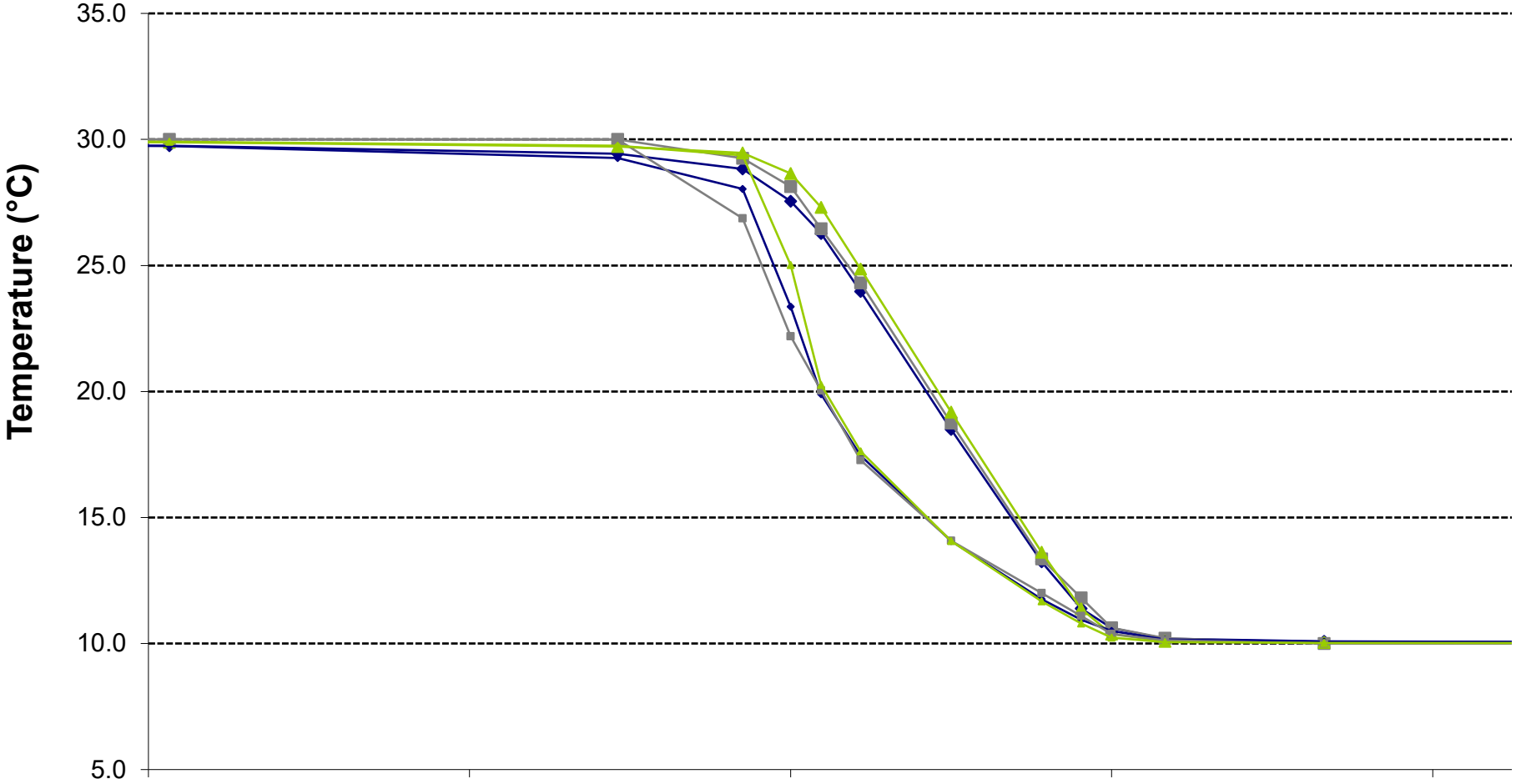

Figure B8.2-12.
IEA BESTEST: In-Depth Floor Slab, GC30b, GC60b, GC65b
Steady-State Near-Surface Temperatures (Y=0, thru center of edge)

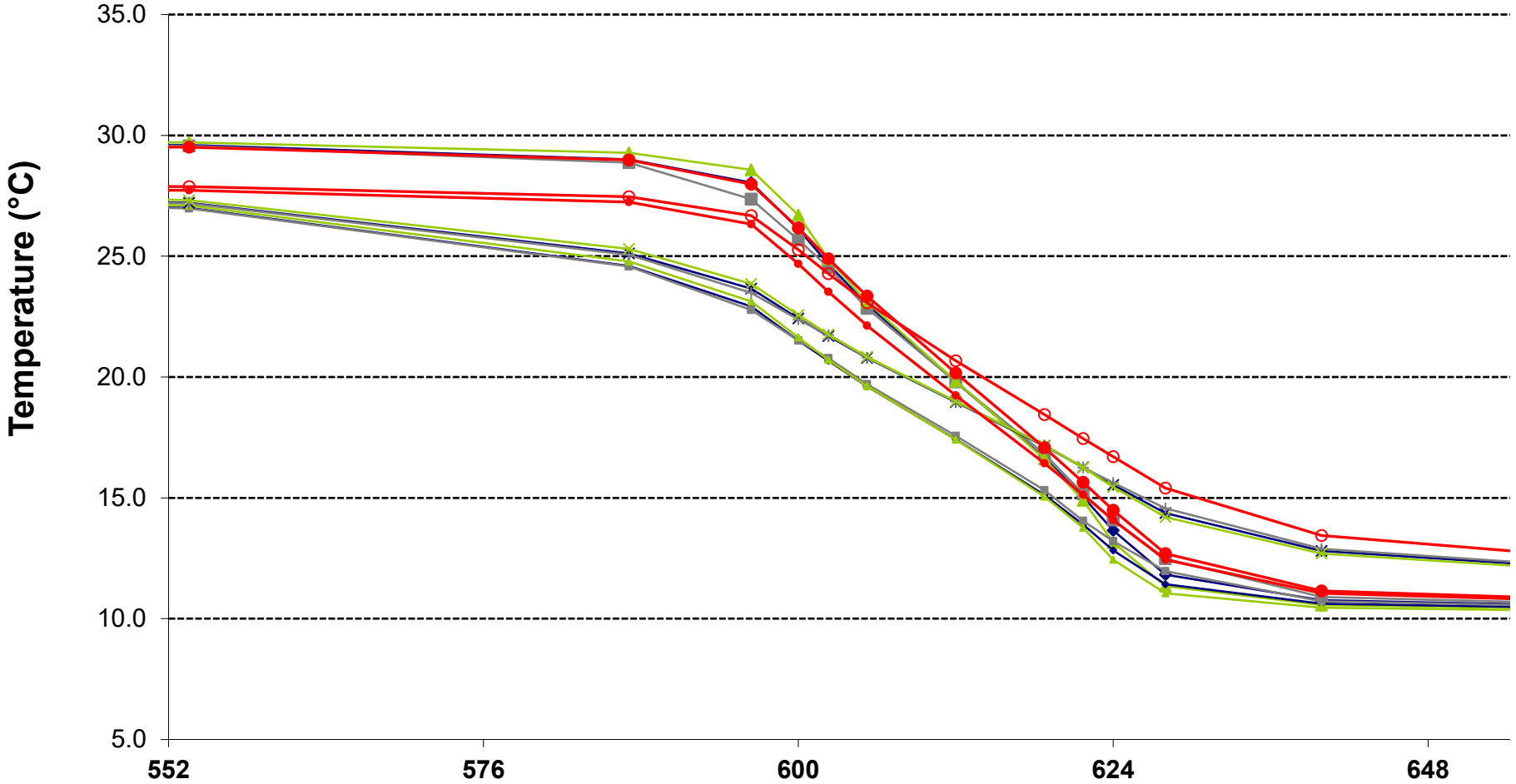

Figure B8.2-13.
IEA BESTEST: In-Depth Floor Slab, GC30b, GC60b, GC65b
Steady-State Near-Surface Temperatures (Y=X, thru corner)

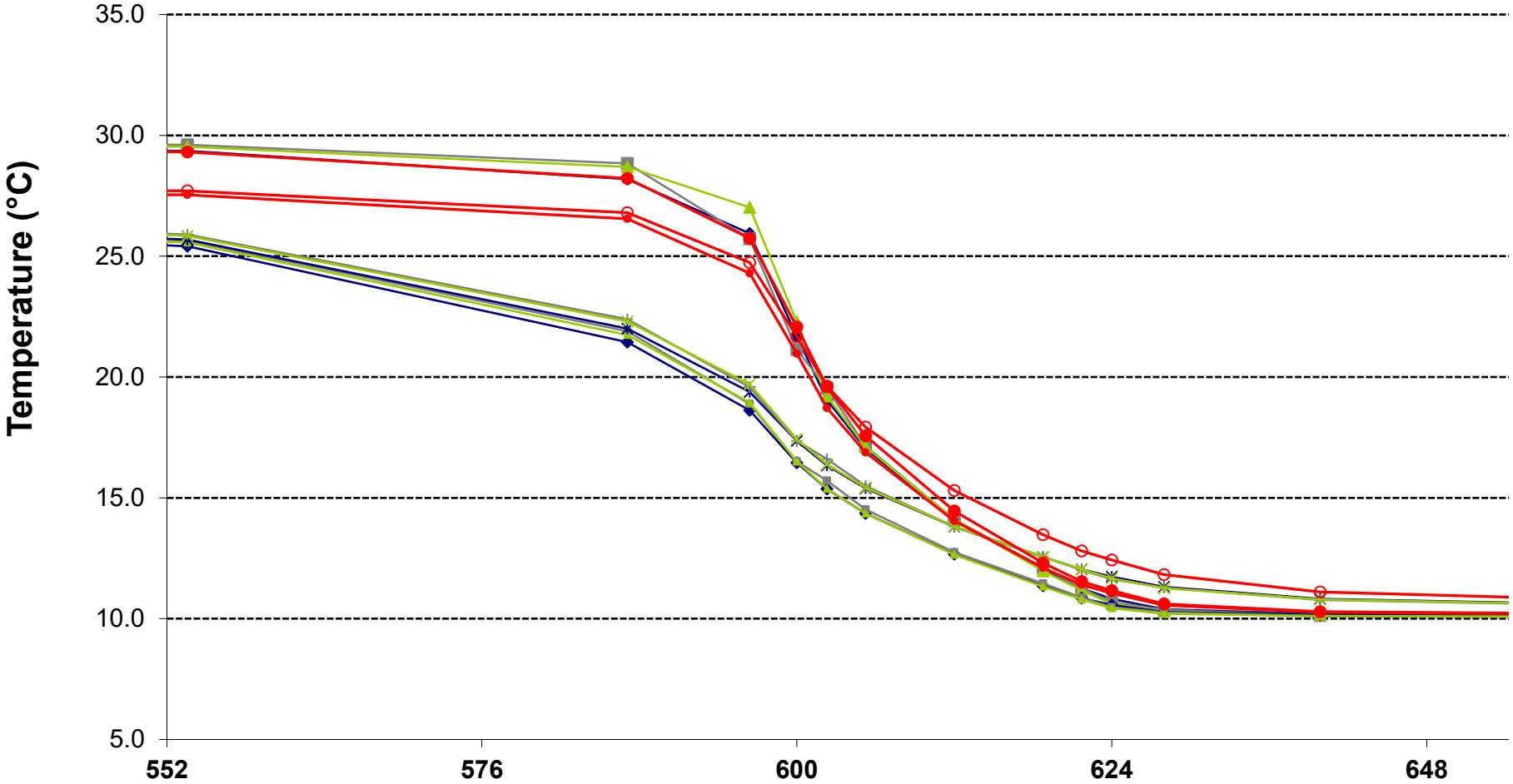

Figure B8.2-14. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Floor Conduction

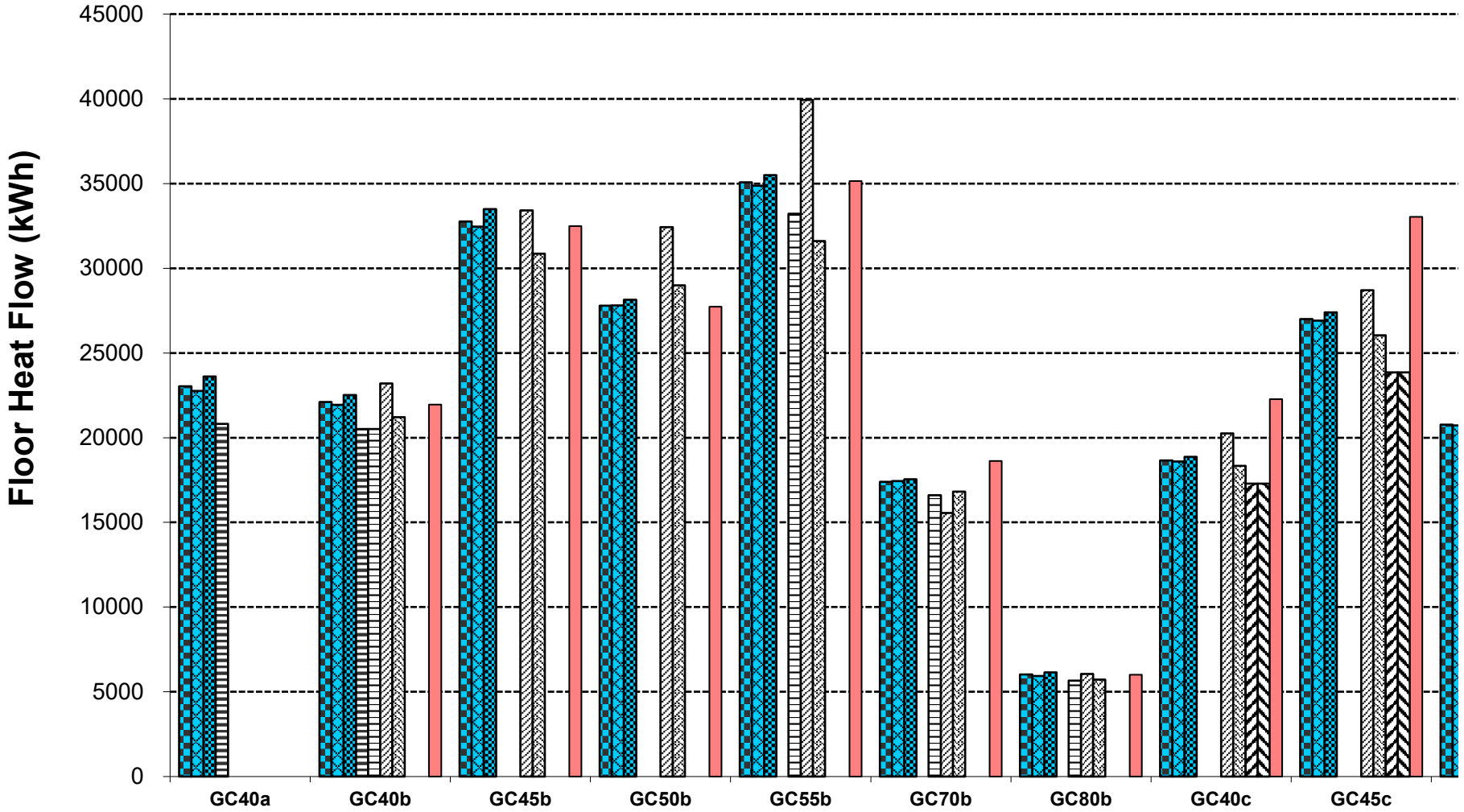

Figure B8.2-15. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Floor Conduction Sensitivity

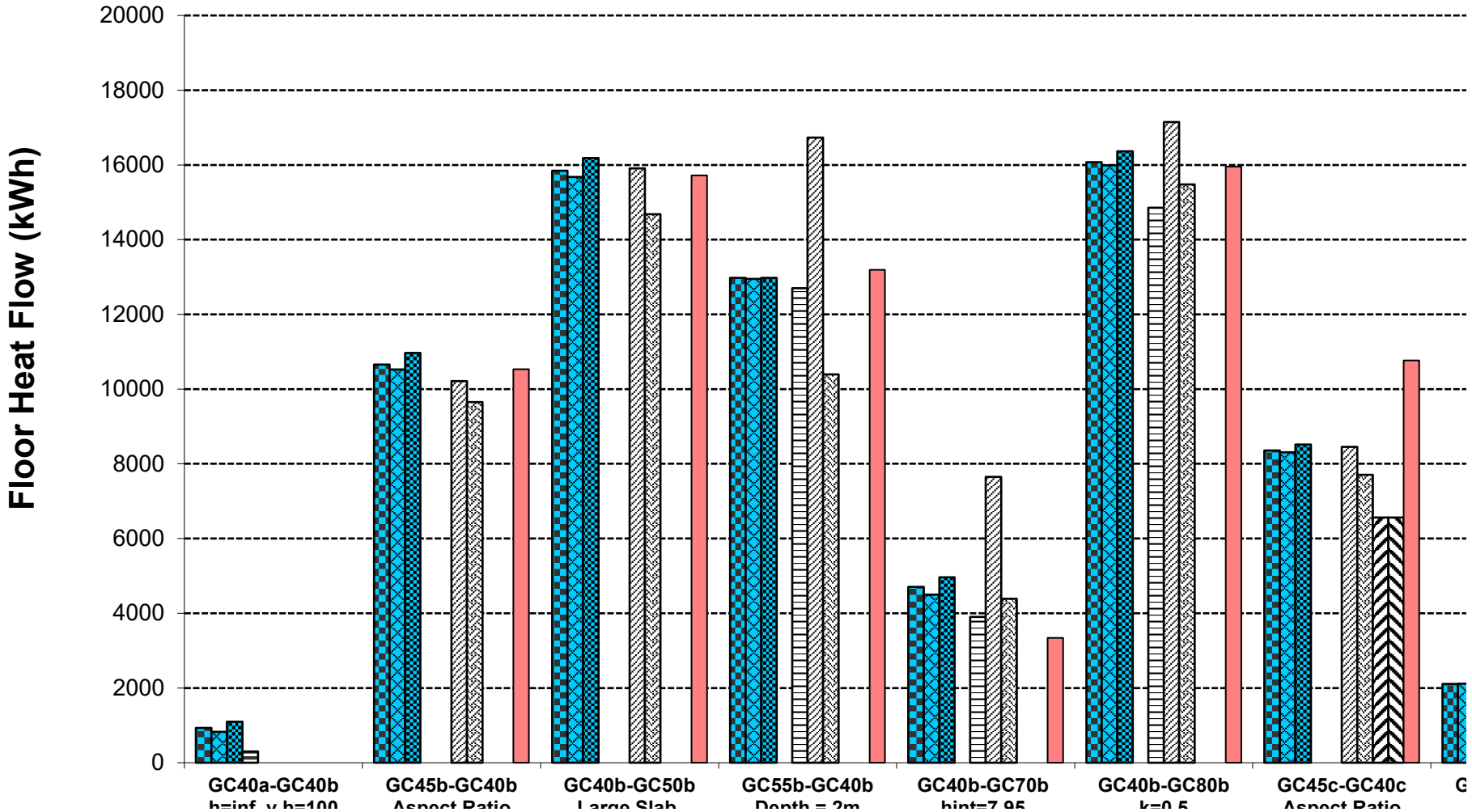

Figure B8.2-16. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Zone Heating Load

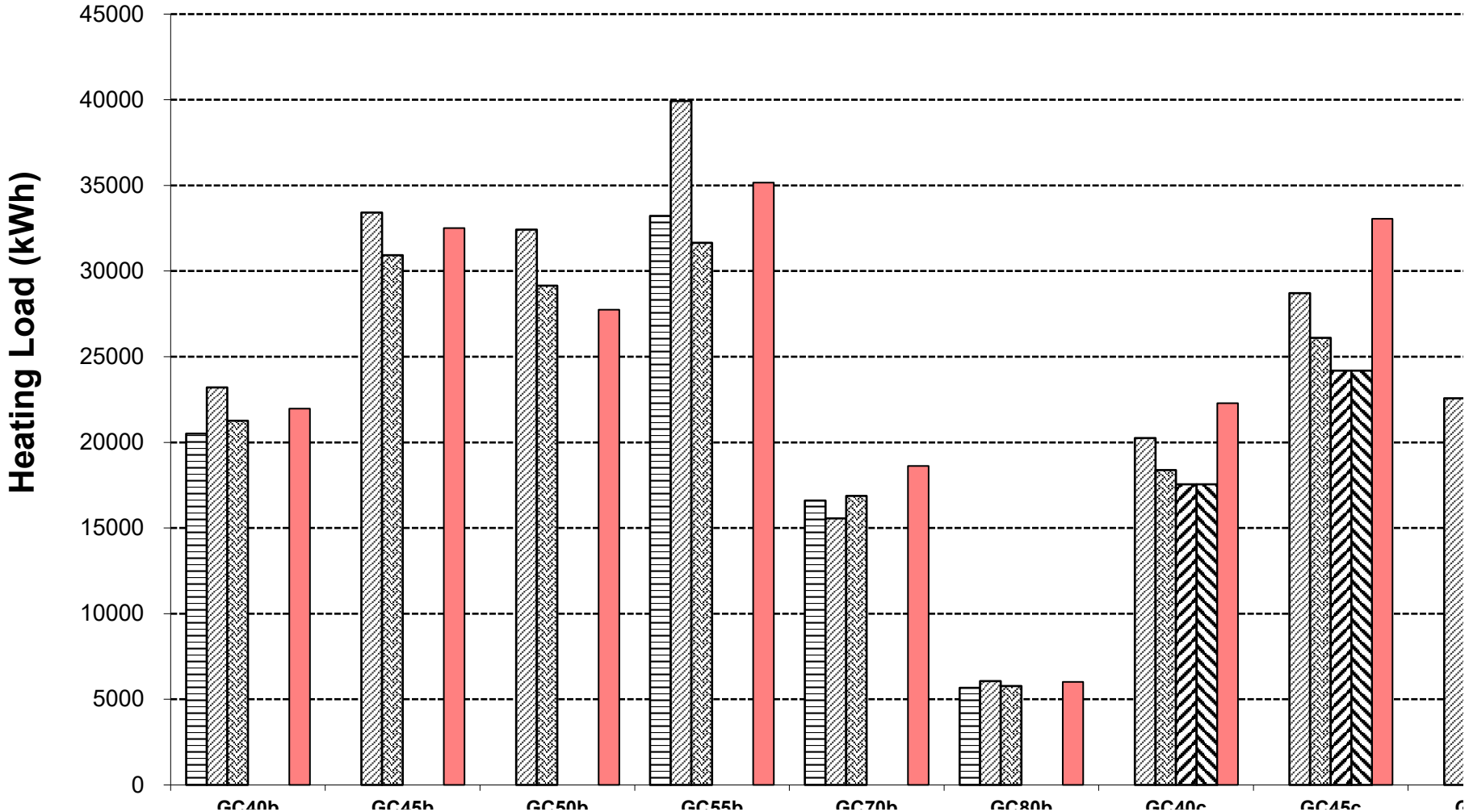

Figure B8.2-17. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Zone Heating Load Sensitivity

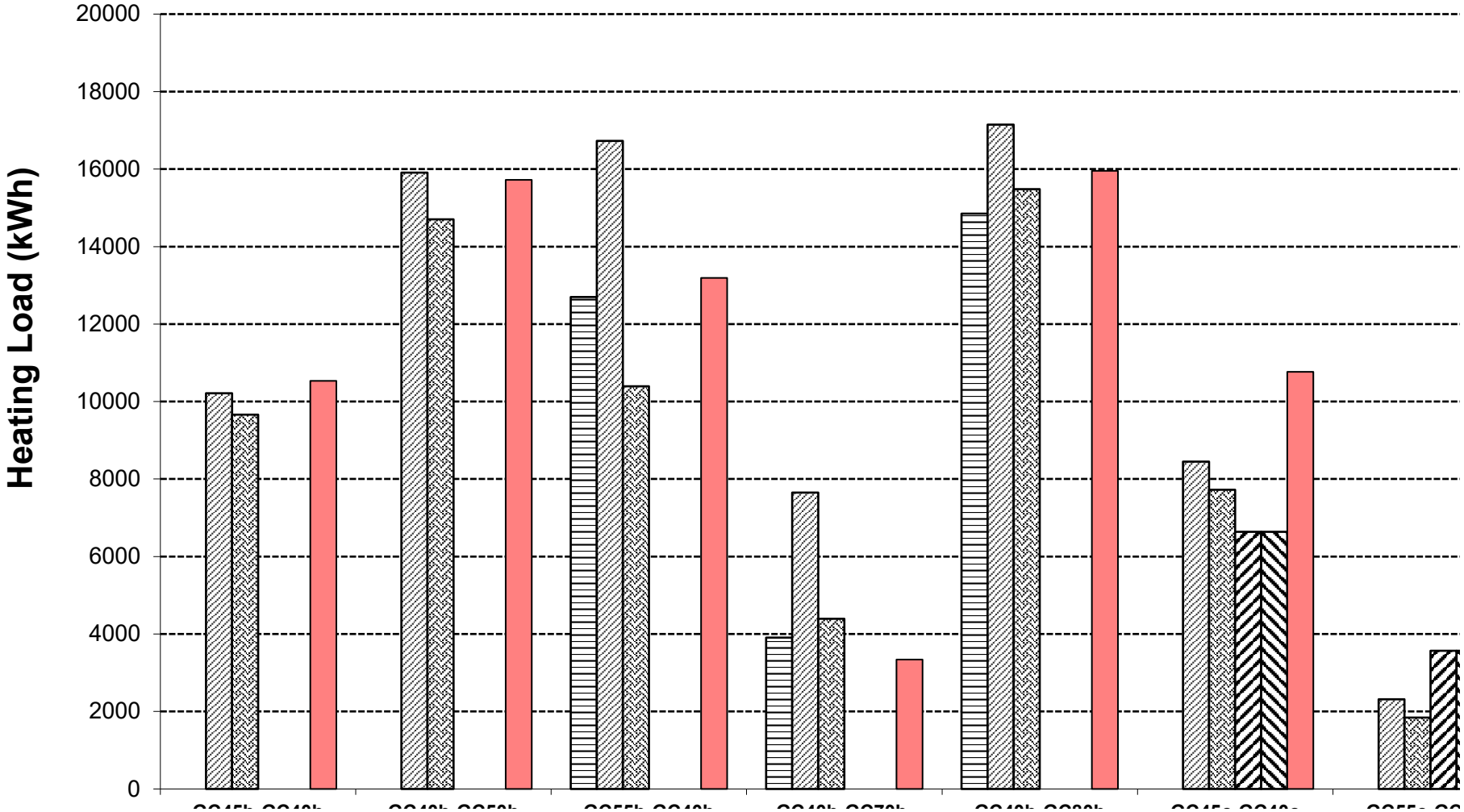

Figure B8.2-18. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic (Zone Heating Load) - (Floor Conduction)

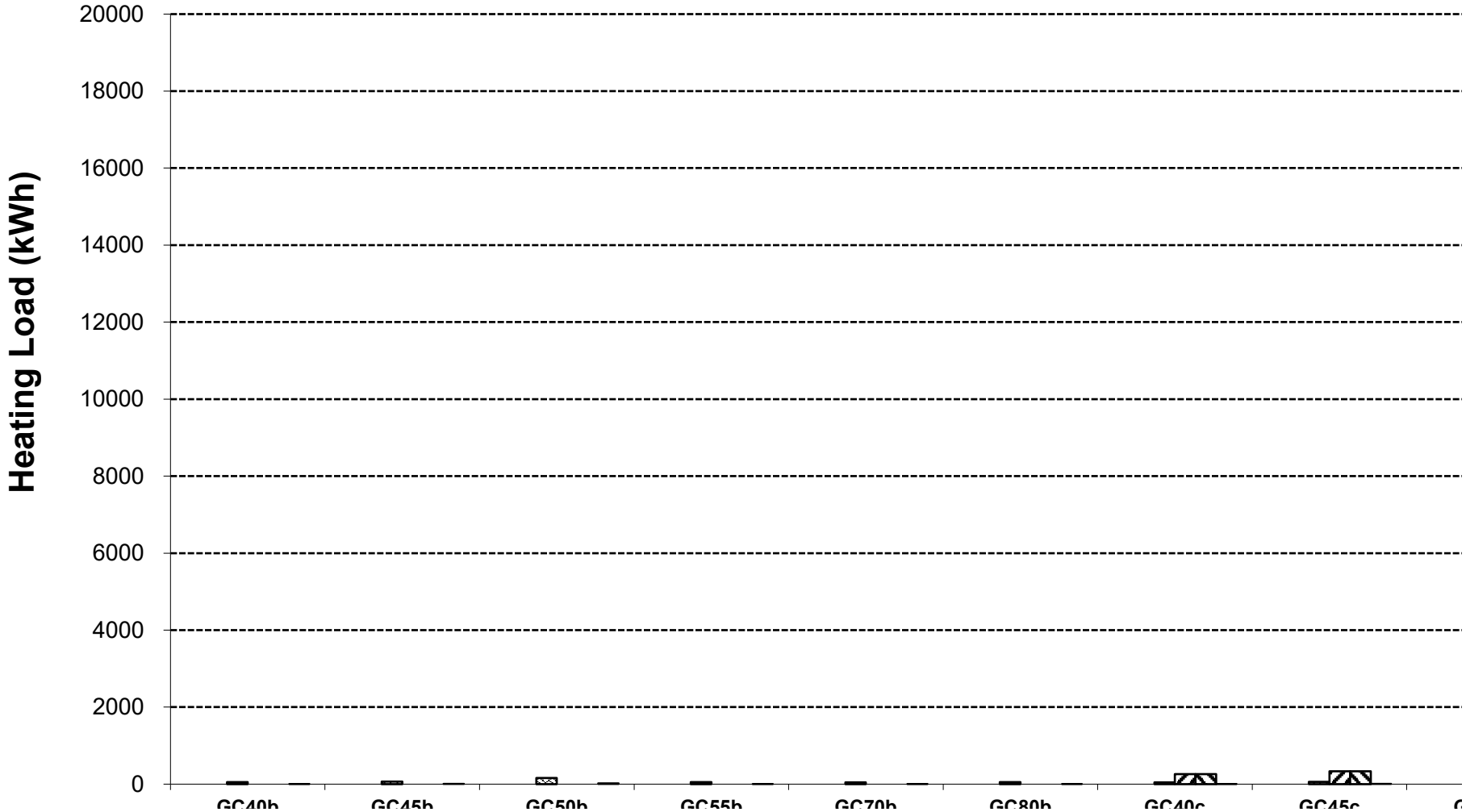

Figure B8.2-19. IEA BESTEST Ground Coupling: In-Depth Floor Slab Hourly Floor Conduction, GC40a

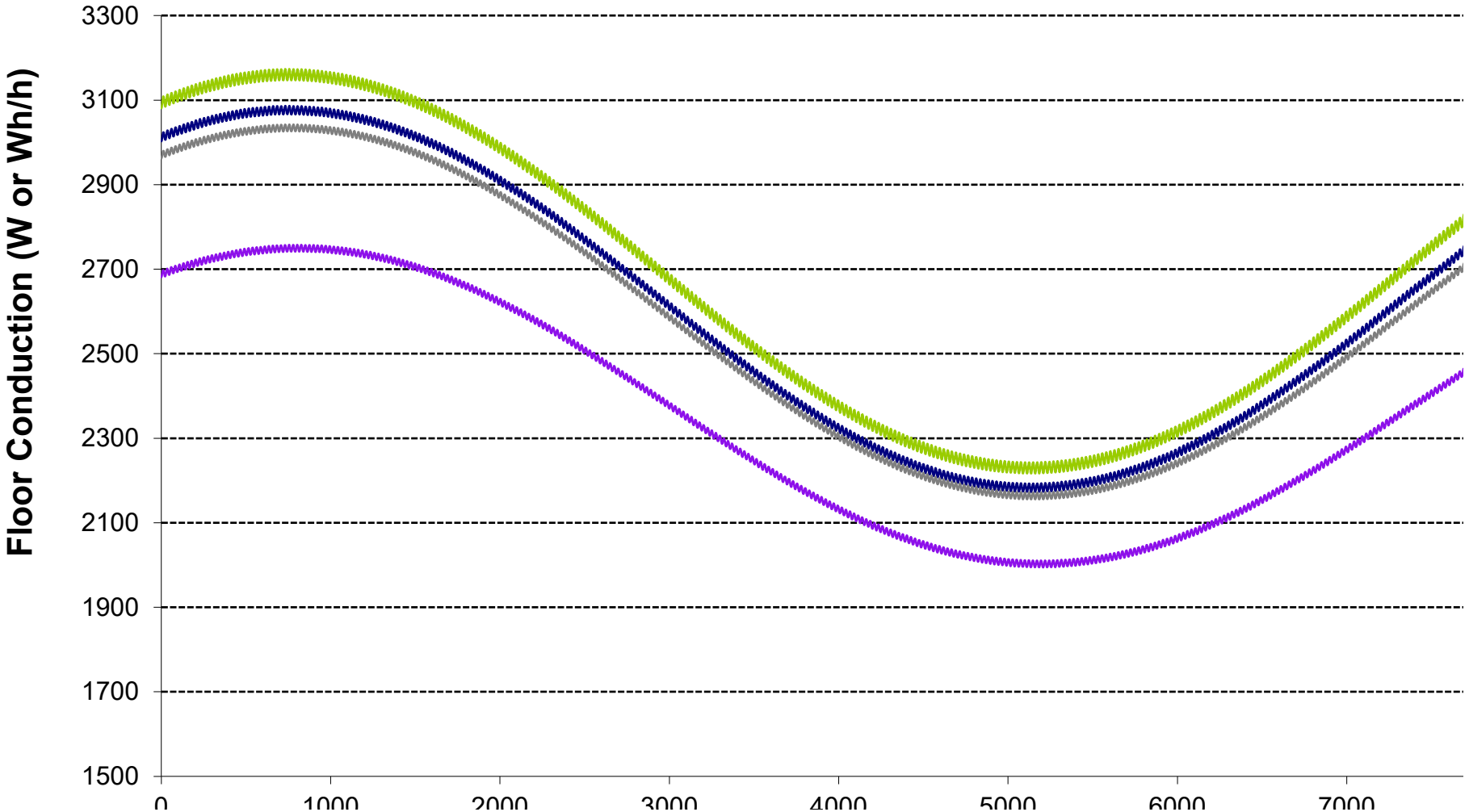

Figure B8.2-20. IEA BESTEST Ground Coupling: In-Depth Floor Slab Hourly Floor Conduction, GC40b

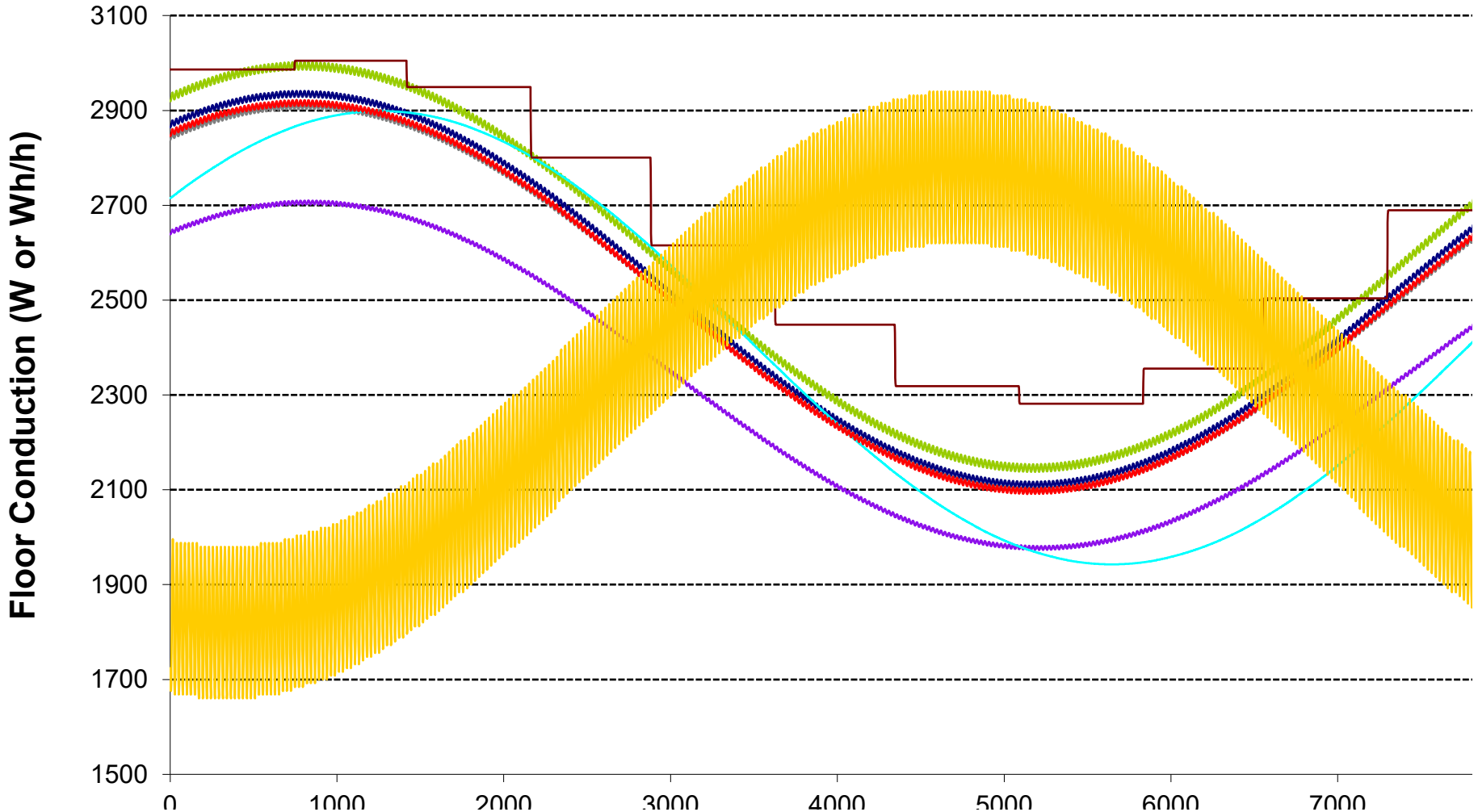

Figure B8.2-21. IEA BESTEST Ground Coupling: In-Depth Floor Slab Hourly Floor Conduction, GC40c

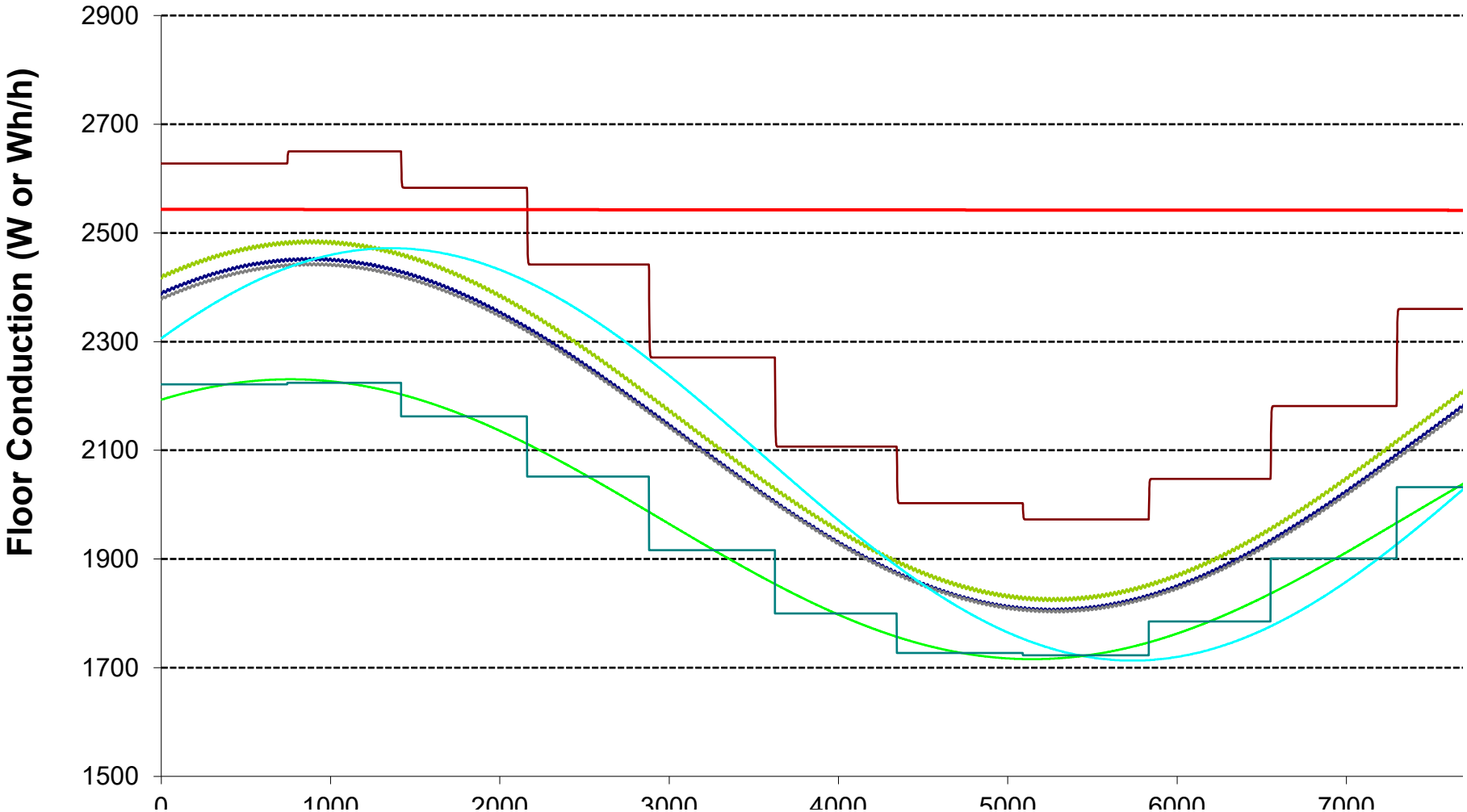

Figure B8.2-22. IEA BESTEST Ground Coupling: In-Depth Floor Slab
Steady-Periodic Phase Shift, Time From Coldest ODB to Peak Floor Conduction

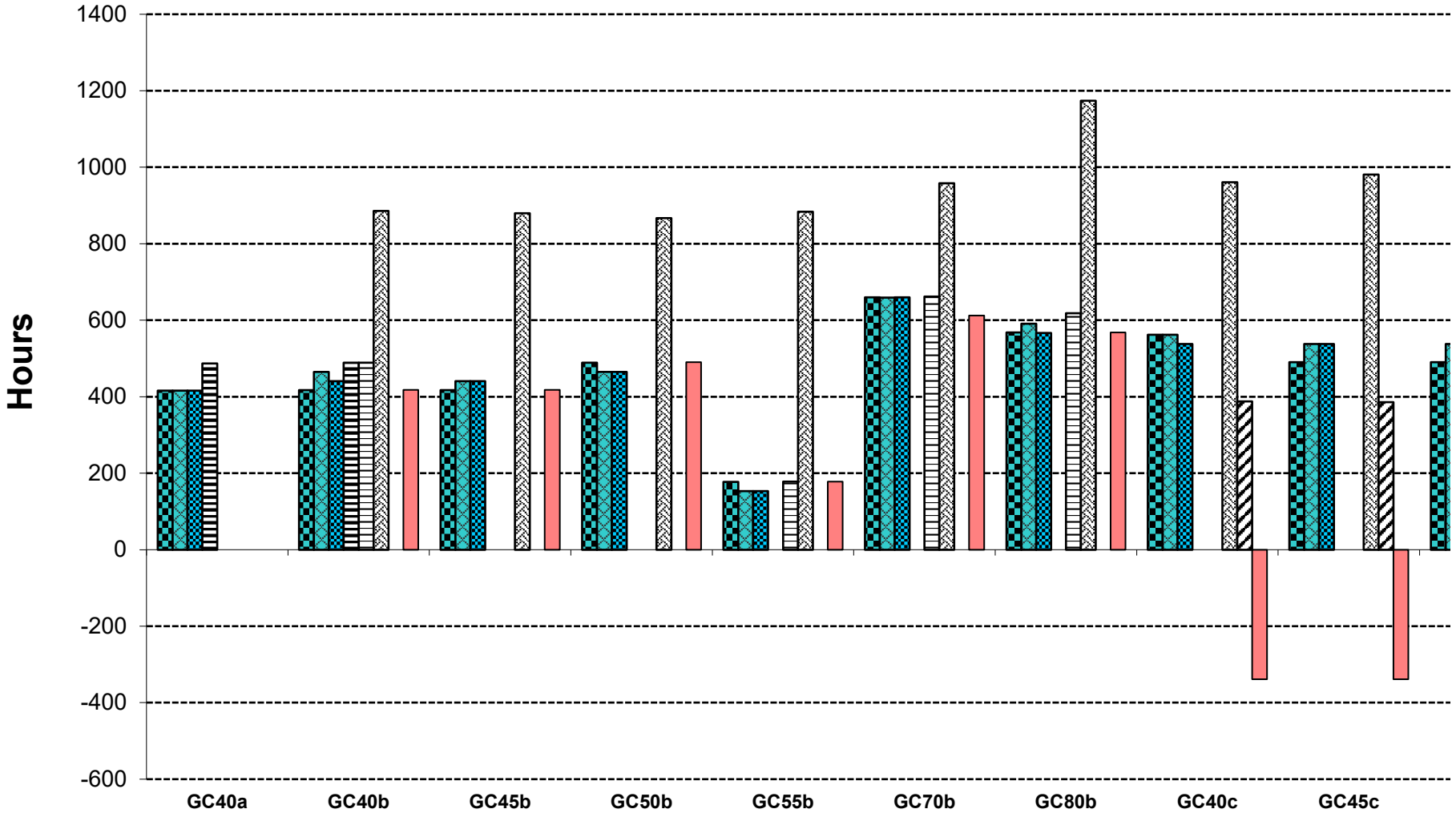

Figure B8.2-23. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Phase Shift Sensitivity, Floor Conduction v. ODB

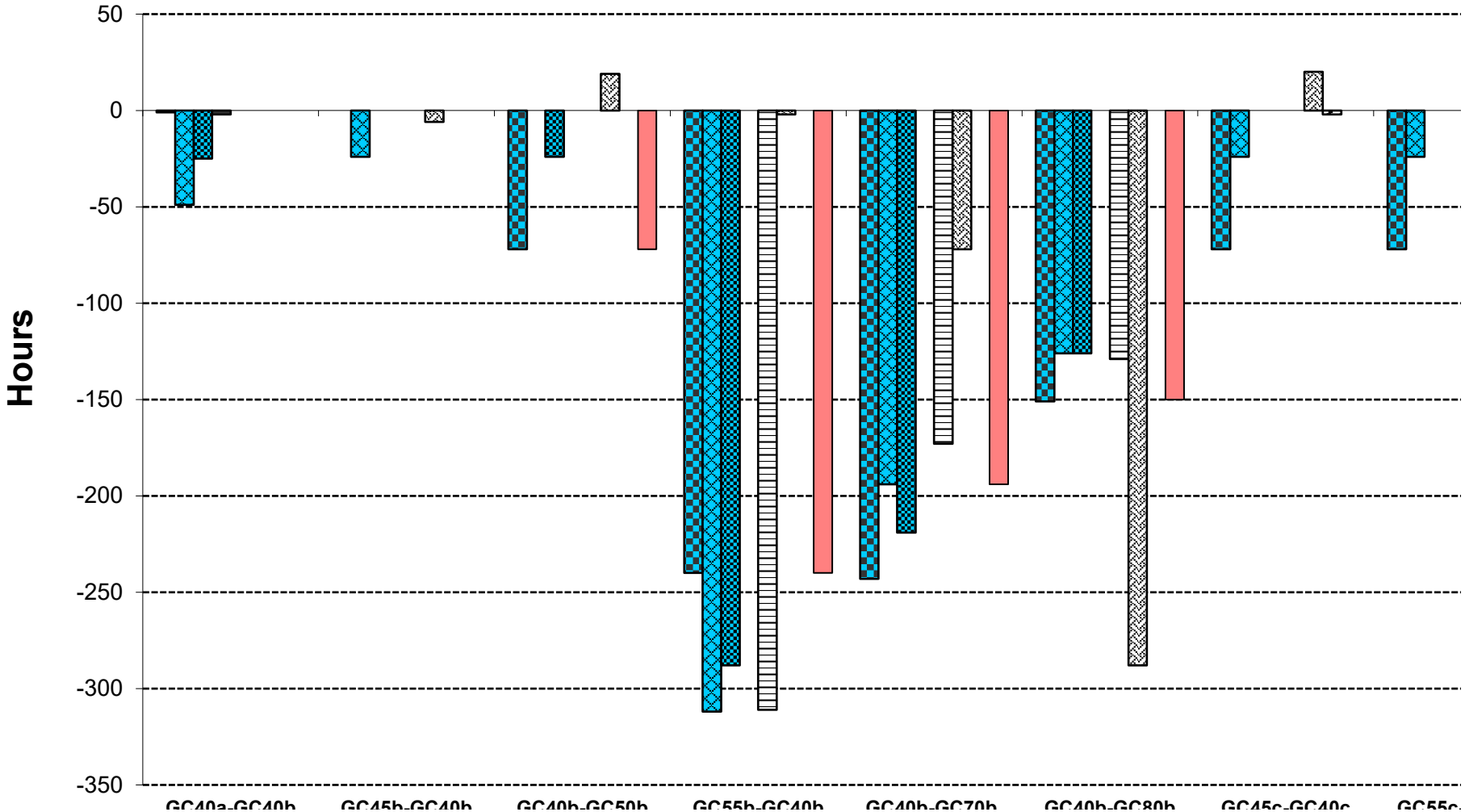

Figure B8.2-24. IEA BESTEST Ground Coupling: In-Depth Floor Slab
Steady-Periodic Phase Shift, Time from Coldest ODB to Peak Zone Load

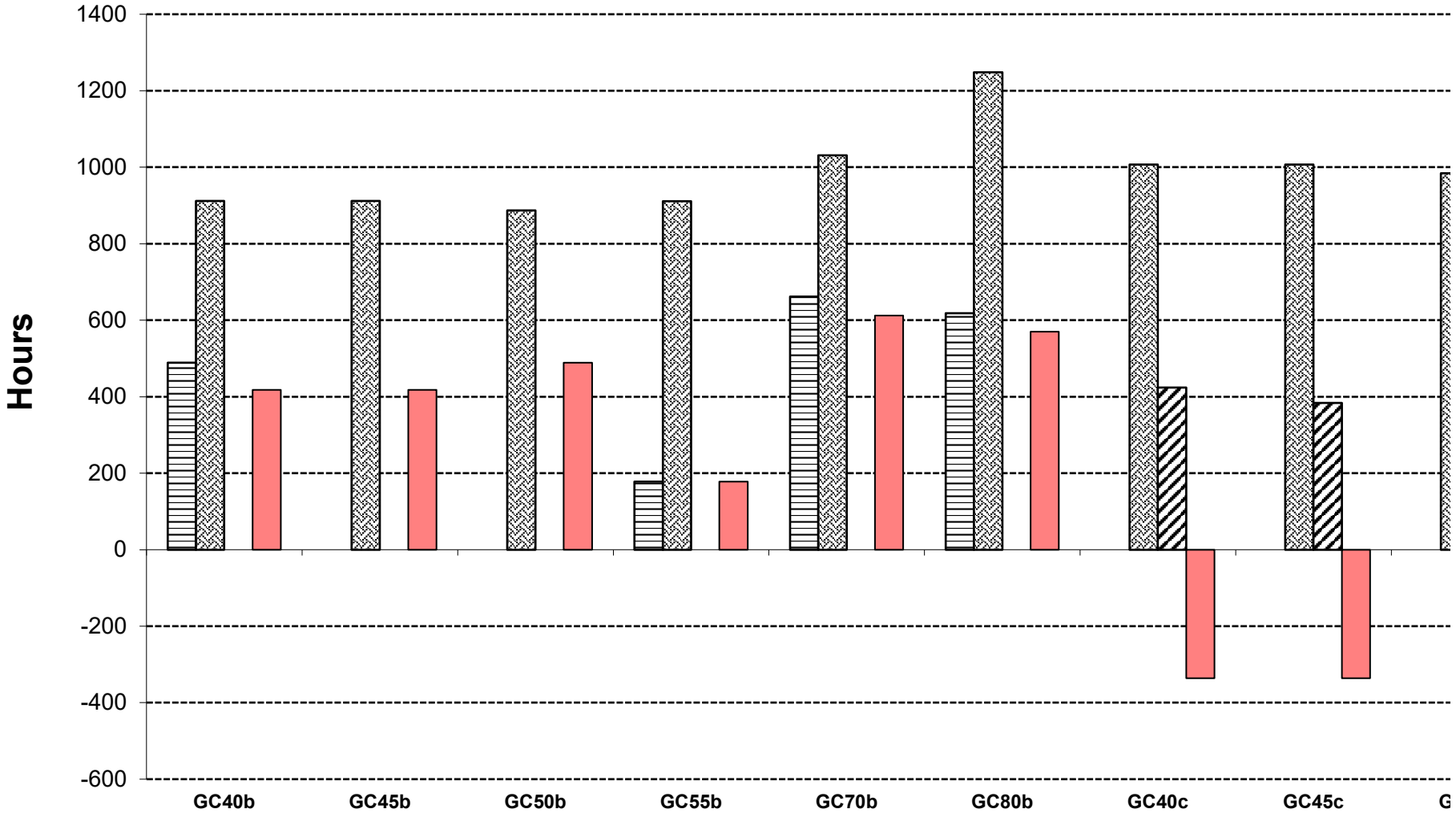

Figure B8.2-25. IEA BESTEST Ground Coupling: In-Depth Floor Slab Delta Steady-Periodic Phase Shift Sensitivity, Zone Load v. ODB

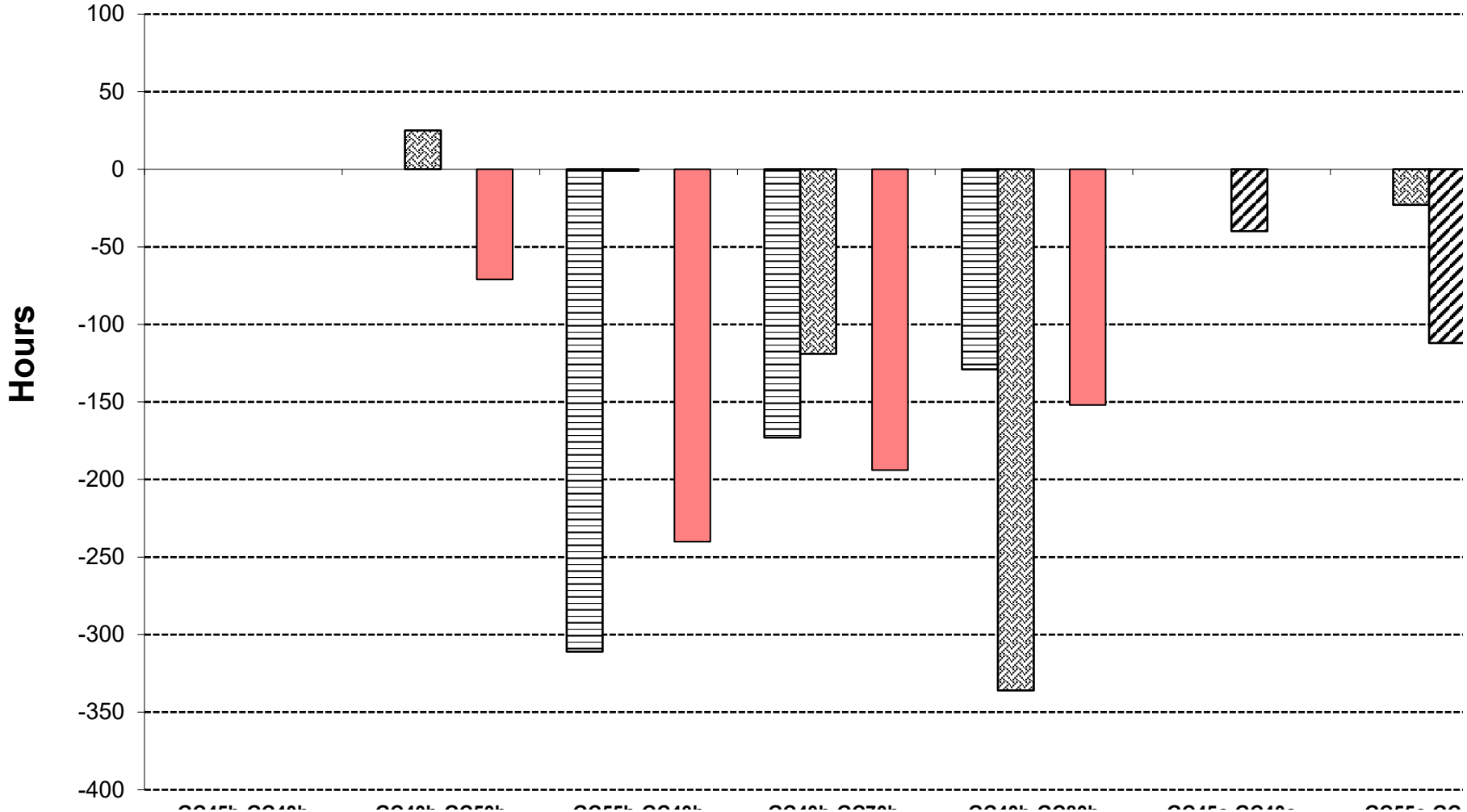

Figure B8.2-26. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Peak-Hour Floor Conduction

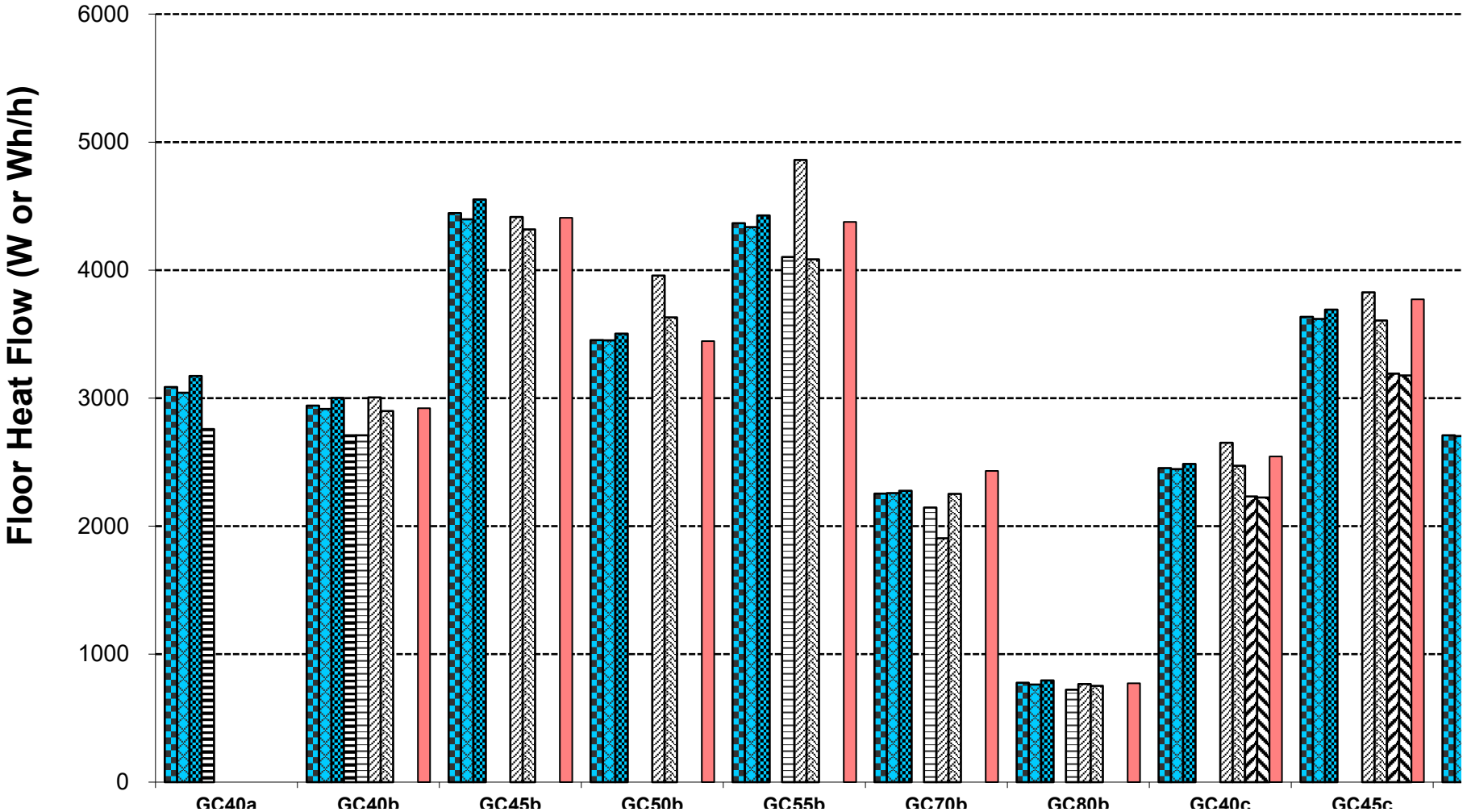

Figure B8.2-27. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Peak-Hour Floor Conduction Sensitivity

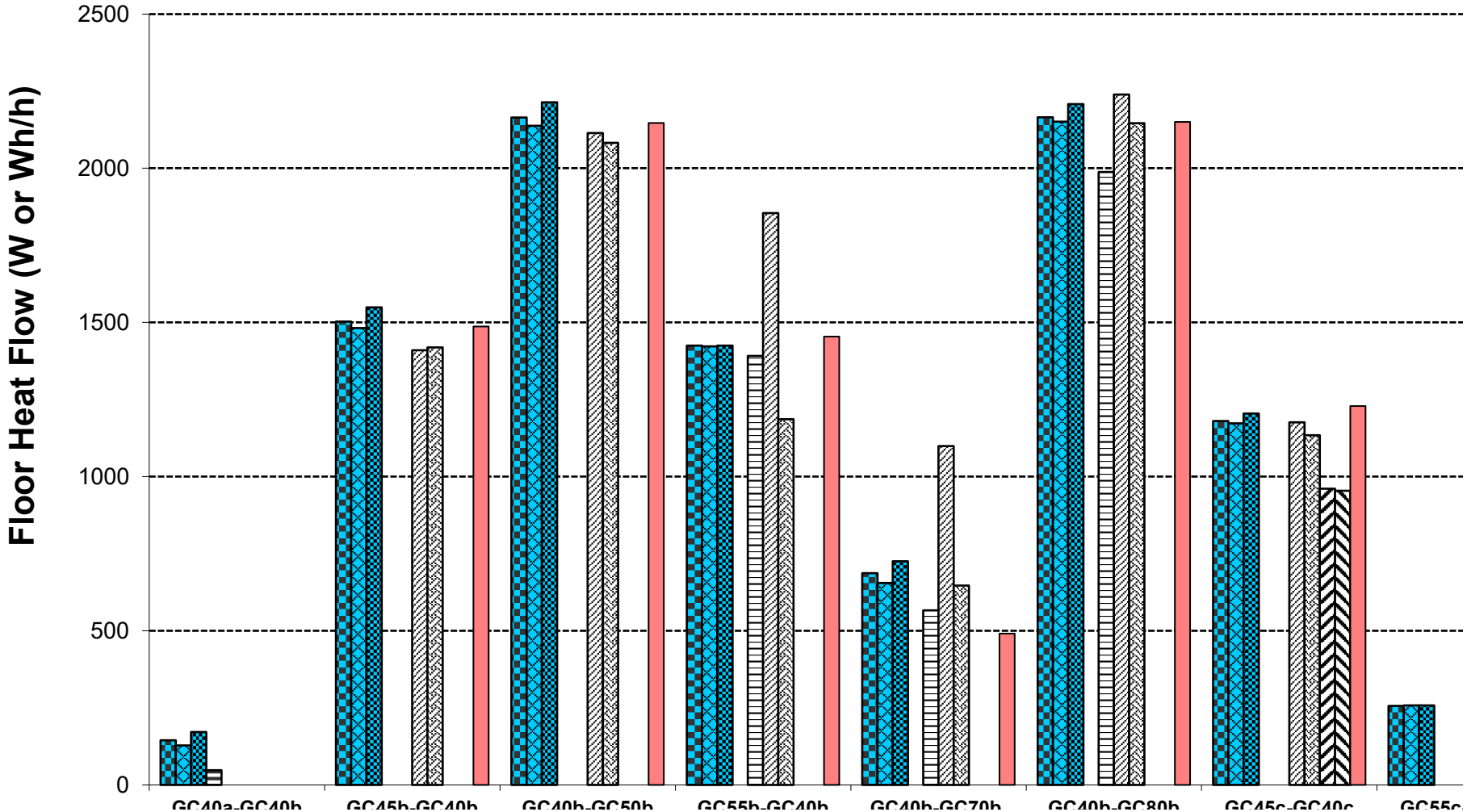

Figure B8.2-28. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Peak-Hour Zone Heating Load

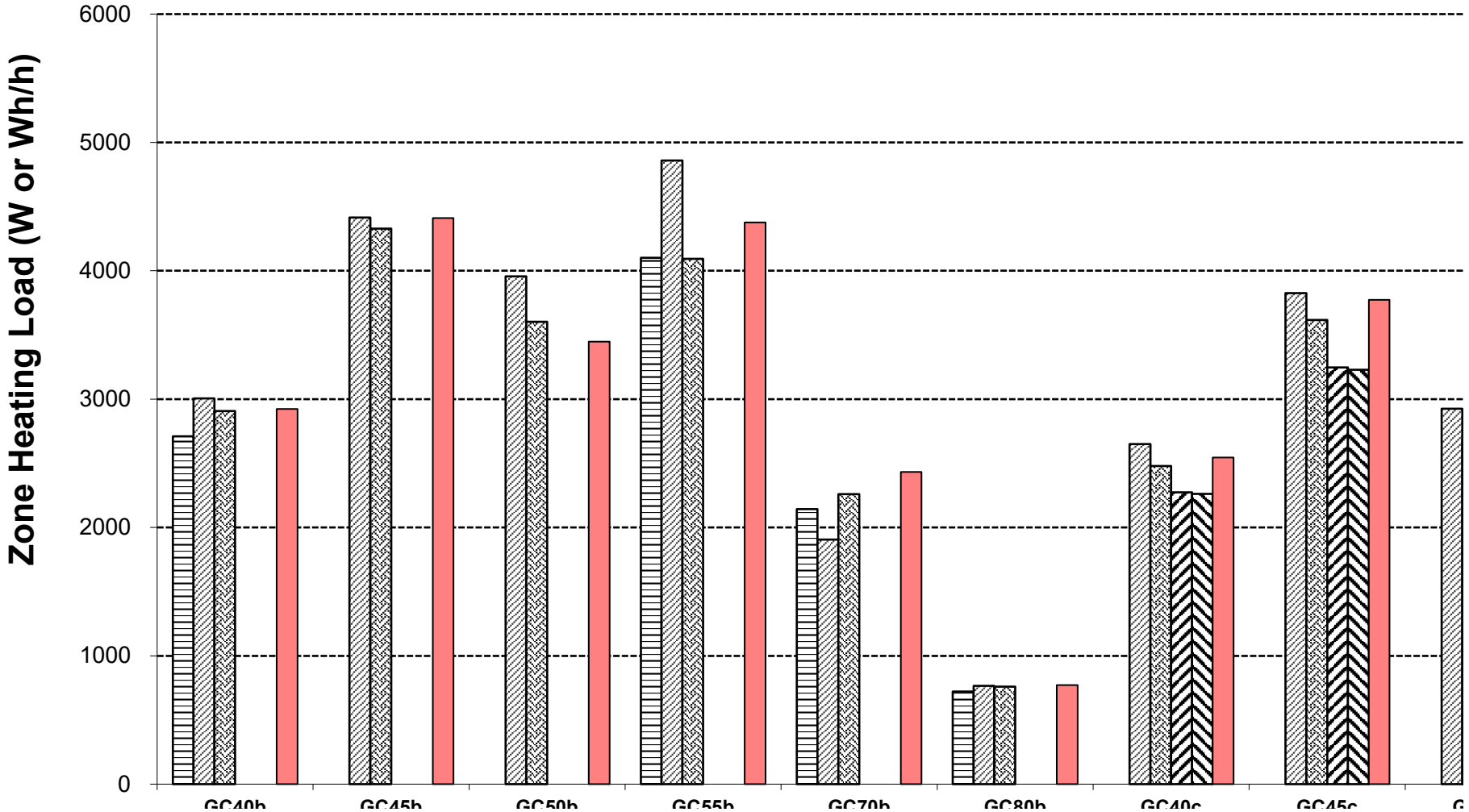

Figure B8.2-29. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Annual Peak-Hour Zone Heating Load Sensitivity

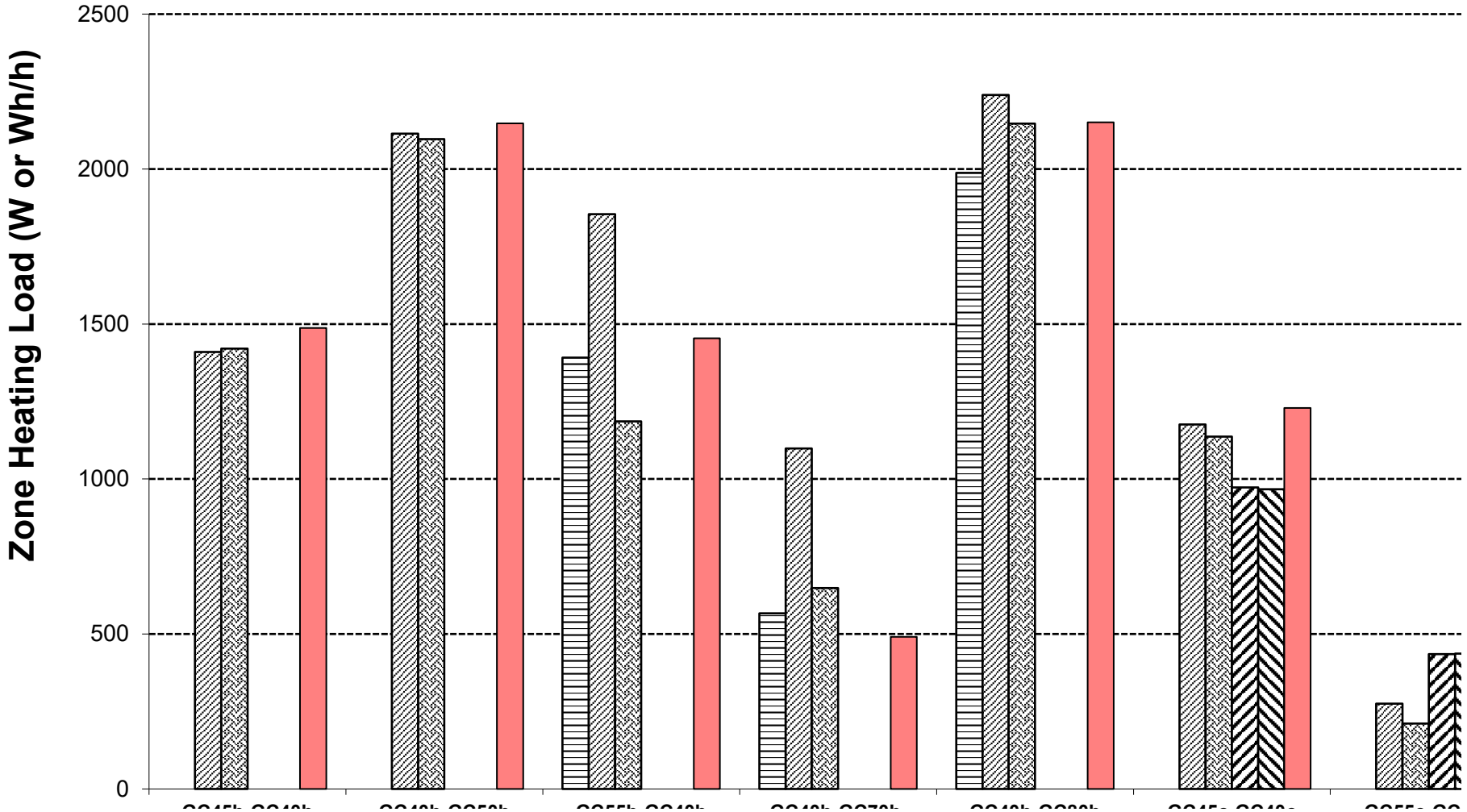

Figure B8.2-30. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic (Peak Zone Heating Load) - (Peak Floor Conduction)

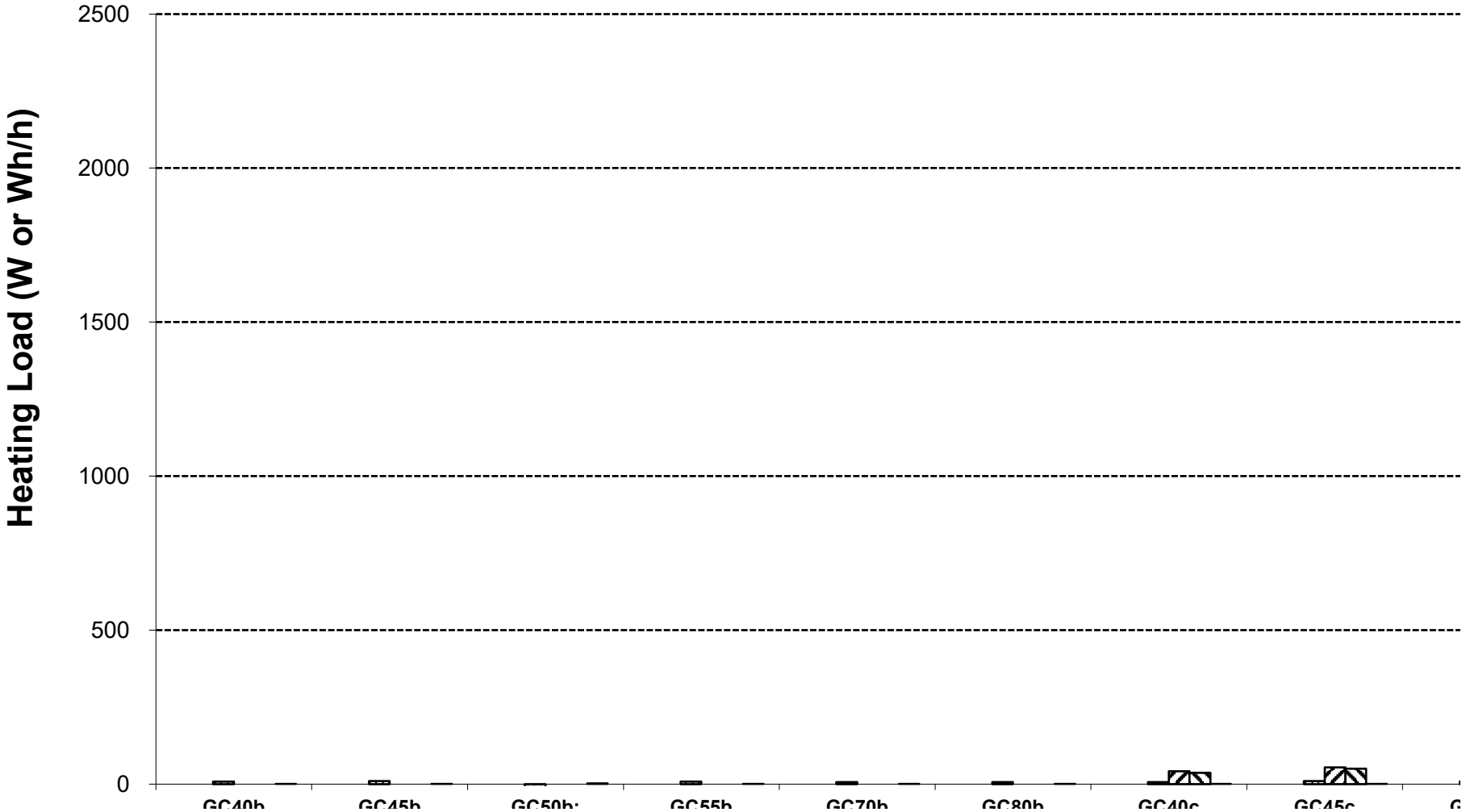

Figure B8.2-31. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Zone Temperature

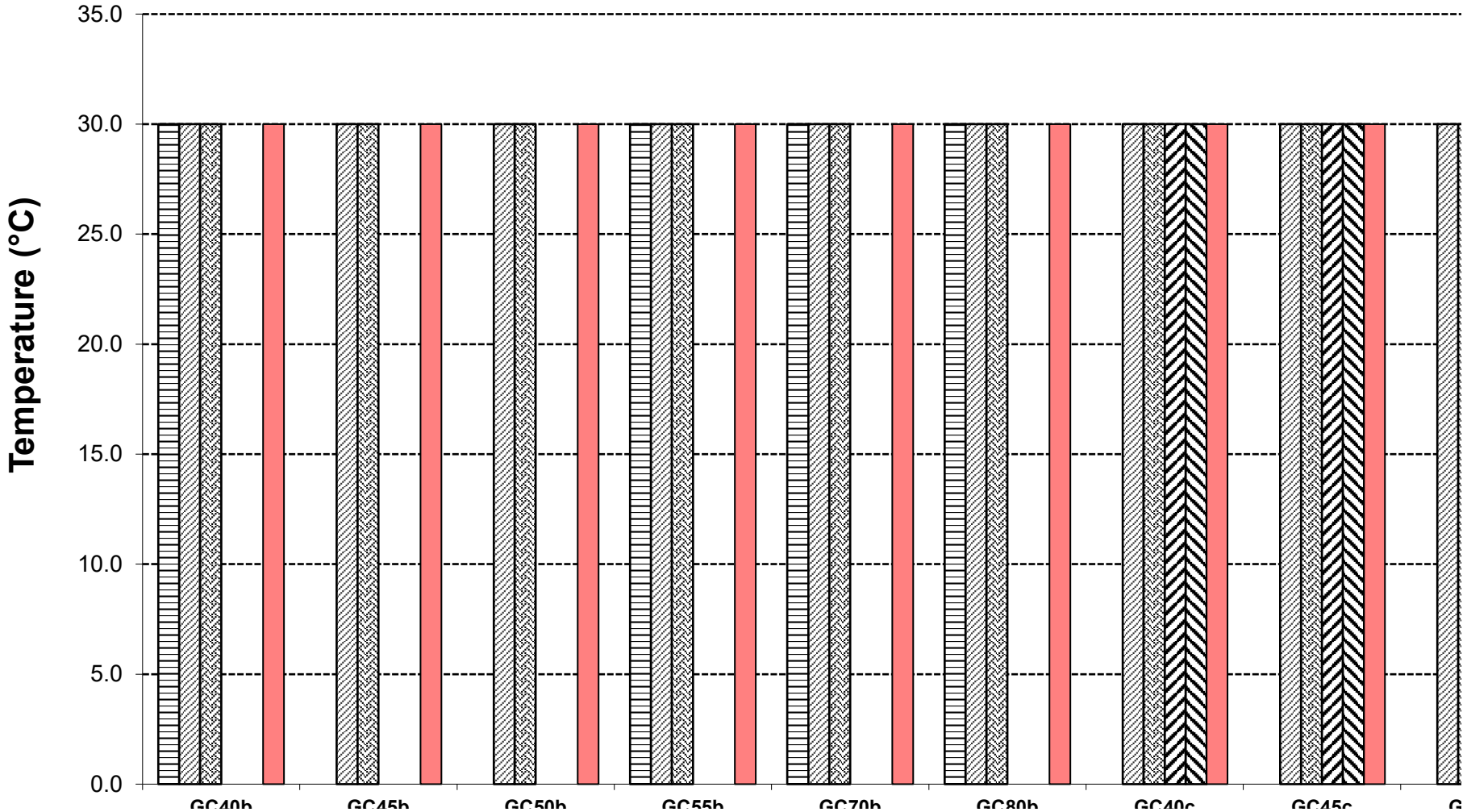

Figure B8.2-32. IEA BESTEST Ground Coupling: In-Depth Floor Slab Steady-Periodic Minimum ODB