INCON – Shear Studs (ISS)

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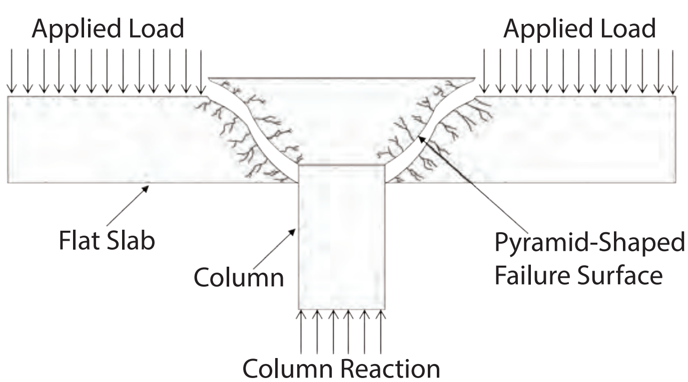
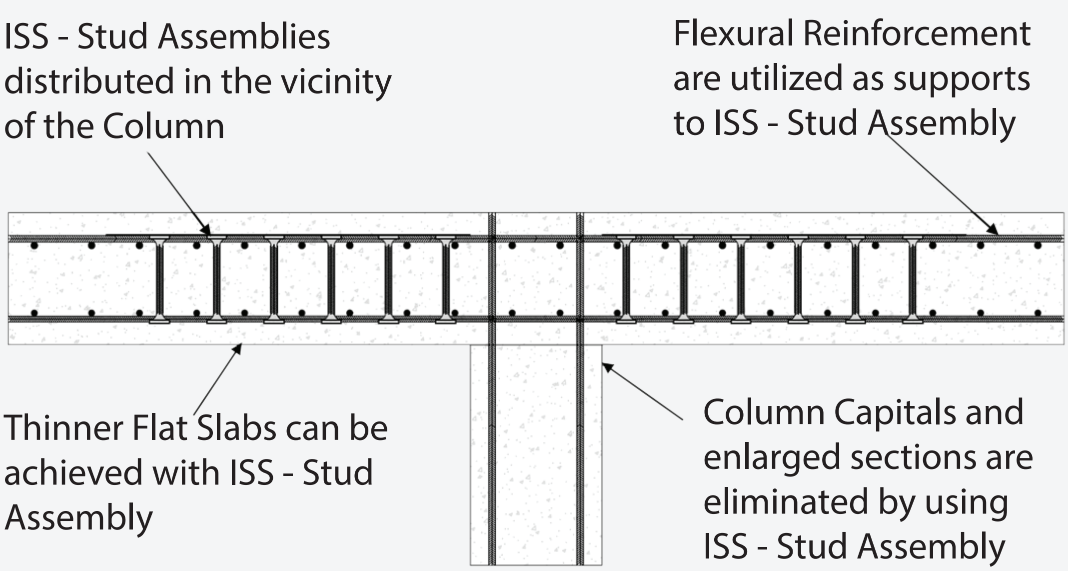
Go Higher and Faster with - ISS

Punching Shear Concept

Punching Shear in Flat Slabs:

- A flat slab is a concrete slab of uniform thickness reinforced in two or more directions and supported directly by columns without beams or girders.
- Shear at column locations governs the thickness of a flat slab. Punching shear is the potentially high shearing stress developed by the reactive force of a column on a reinforced concrete slab.
- These slabs may fail locally under the concentrated load, i.e. a concrete pyramid together with the load or column is punched out from the slab.
- **ISS – Shear Studs** are used as shear reinforcement to significantly increase the shear capacity of slabs and eliminate premature failure.

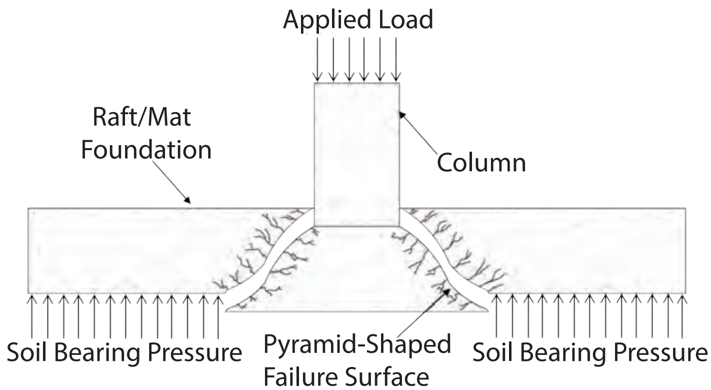


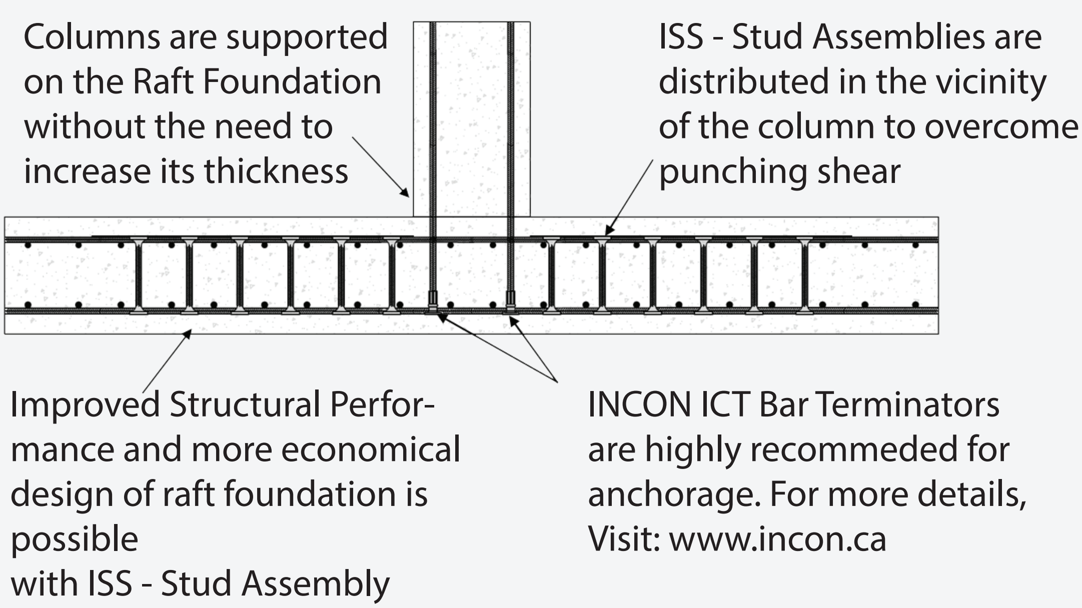


Punching Shear Concept

Punching Shear in Raft/Mat Foundations:

- A raft/mat foundation is a thick, heavily reinforced concrete slab that serves as a single monolithic footing for a number of columns or an entire building.
- Due to the existence of large soil pressure under the foundations, high shear stresses are developed in the vicinity of the columns. ISS - Shear Studs are used in order to overcome such stresses without increasing the thickness of the foundation.
- When shear studs are not used, the foundations may fail locally under the concentrated load in a manner that causes penetration of the columns through the foundations.
- **ISS – Shear Studs** are used as shear reinforcement to significantly increase the shear capacity of foundations in the vicinity of the columns and to eliminate premature failure at those sections.

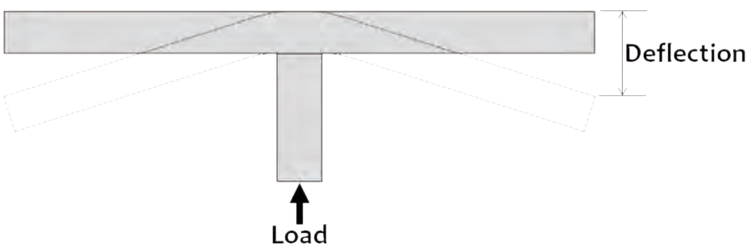


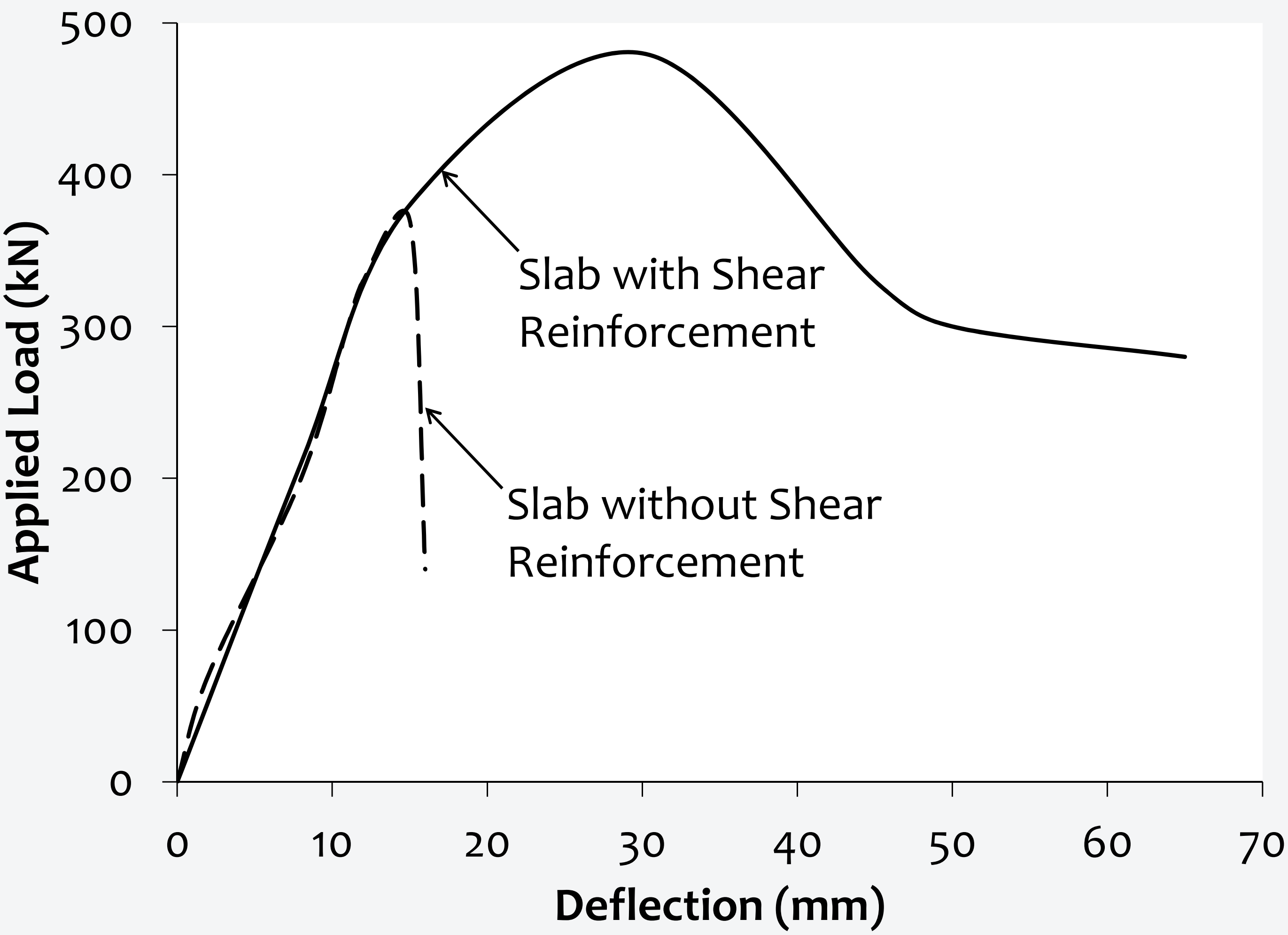


Shear Reinforcement

Importance of Shear Reinforcement:

- An experimental program* performed on RC slab-column connections clearly shows the substantial influence of shear reinforcement on enhancing both punching shear resistance and ductility of the slabs.

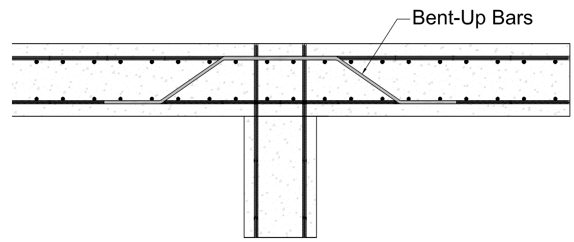




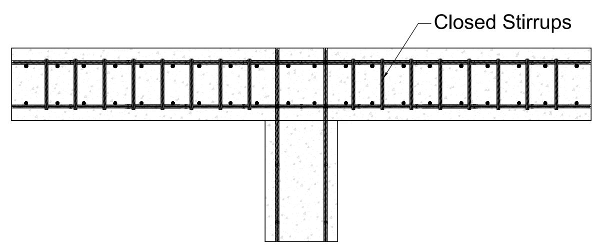
* Dilger, WH and Ghali, A., 1981, Shear Reinforcement for Concrete Slabs, ASCE Journal of Structural Division, V. 107, pp. 2403-2420.

Conventional Shear Reinforcement Methods

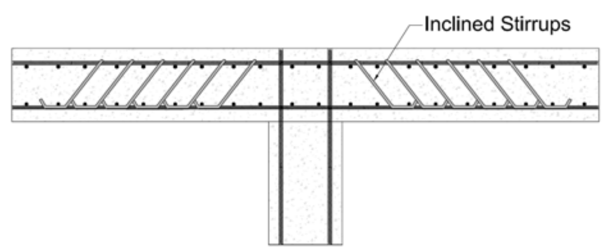
Bent-Up Bars:
- Increase reinforcement congestion.
- Require special detailing.
- Increase cut and bend time.



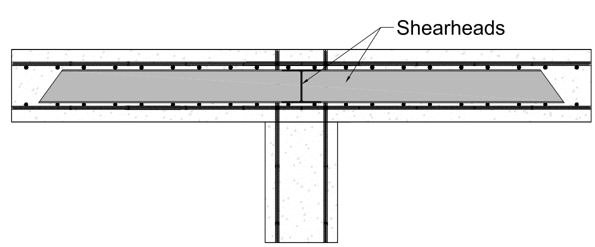
Closed Stirrups:
- Increase reinforcement congestion.
- Require lengthy installation time.
- Increase cut and bend time.
- Labor Intensive



Inclined Stirrups:
- Increase reinforcement congestion.
- Require special detailing.
- Increase cut and bend time.
- Increase installation time.
- Increase design duration due to the additional calculations involved.



Shearheads:
- Act as barriers between bars.
- Require special detailing.
- Increase reinforcement congestion.
- Increase material cost.

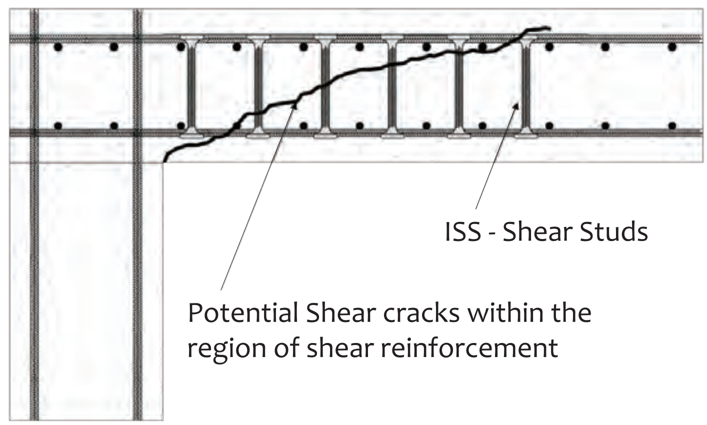


Shear Failure Prevention with ISS – Shear Studs

■ First Mechanism:

Potential shear cracks are within the region of shear reinforcement.

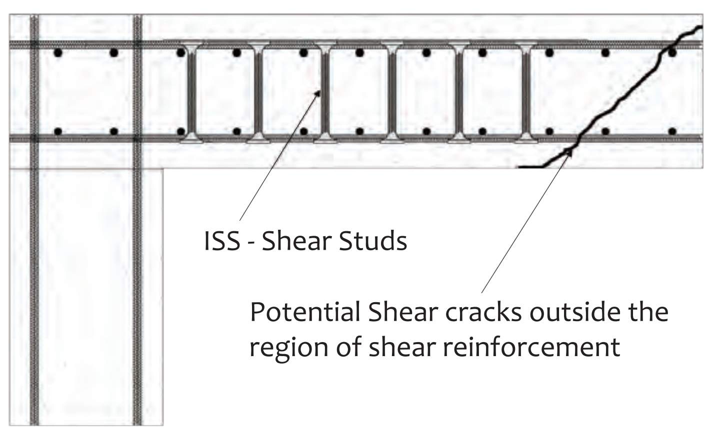
- ISS – Shear Studs are required to intercept shear cracks and prevent them from widening.



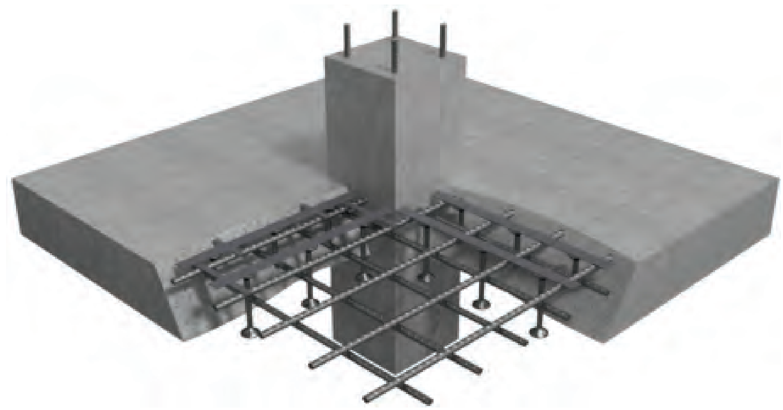
■ Second Mechanism:

Potential shear cracks are outside the region of shear reinforcement.

- Providing ISS – Shear Studs can hinder the formation of shear cracks within the shear reinforced zone and transfer them to the outer region where concrete possesses sufficient contact surface to resist shear stresses alone.



ISS – Shear Stud Assemblies



- ISS – Shear Studs are manufactured under the strictest Canadian Quality Control guidelines and in accordance with ISO 9001:2008 Quality Assurance and Management System.

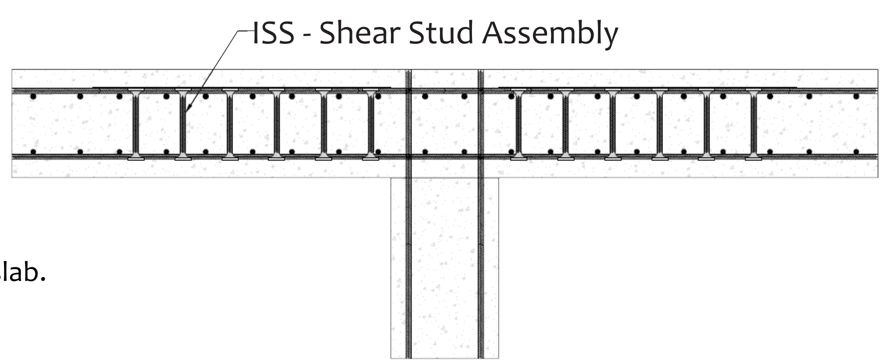
- ISS – Shear Studs provide an outstanding structural performance compared to conventional shear reinforcement due to the enhanced mechanical anchorage provided by their headed ends.

- This improved end anchorage controls the shear crack width and therefore enhances aggregate interlock between the two shear faces.

- When double headed studs are used in flat slabs with continuous top and bottom reinforcement over the column, this also improves the ductility and therefore the shear force at which the diagonal shear crack forms.

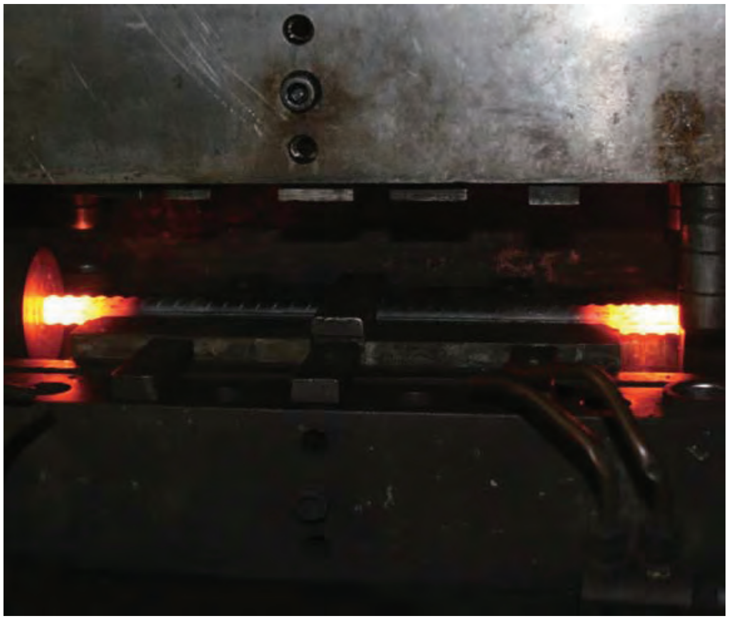
Main Advantages:

- Reduce reinforcement congestion.
- Decrease Construction Time.
- Eliminate extra cut and bend works.
- Enhance structural performance.
- Allow greater design flexibility.
- Reduce slab thickness.
- Provide enhanced anchorage to the slab.
- Ensure factory quality control.
- Reduce material and labor cost.
- Easy to design using **ISS Software**.
- Easy to check and modify arrangement.



Production of ISS - Shear Studs

- An ISS - Shear Stud consists of a deformed reinforcing bar which is hot forged from both sides.
- Studs are manufactured from steel conforming to ASTM A615 and ASTM A706, Grade 60.
- ISS Base Rail is manufactured in accordance with ASTM A1044 to be sufficiently stiff to hold the studs in the appropriate location, direction and spacing.
- The manufacturing process ensures outstanding structural performance of ISS – Shear Stud Assemblies.
- By implementing value engineering in our design and manufacturing process, we ensure that our clients receive high quality products with minimum cost.
- Finished ISS – Shear Studs are of uniform quality and condition, free of discontinuous laps, seams, fins, or other discontinuities.

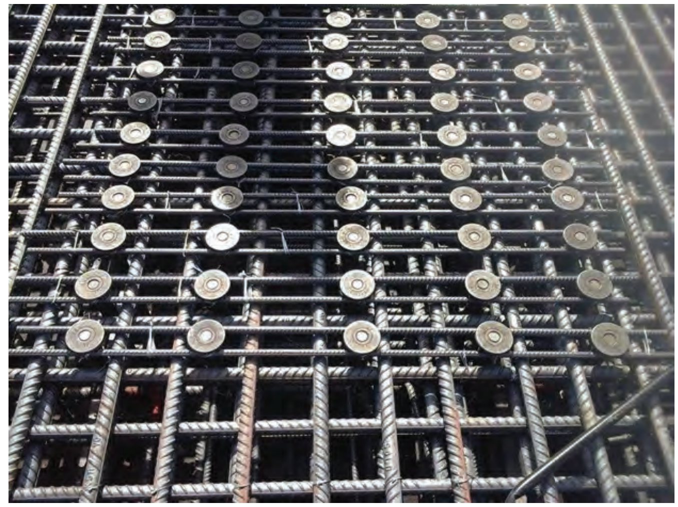


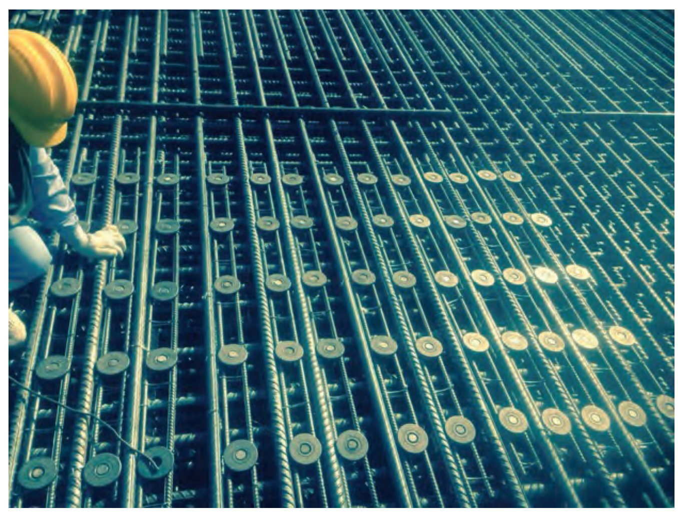
Characteristics of ISS - Shear Studs

- ISS - Shear Studs are mechanically anchored at each end by a head bearing against the concrete in such a way that it is capable of developing the full yield strength of the bar.

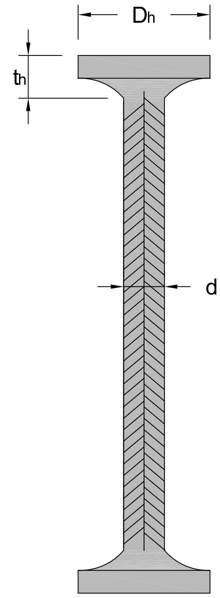
- The dimensions of ISS – Shear Studs are chosen to satisfy the requirements of ASTM A1044, ACI 318-14 and CSA A23.3-14 by ensuring that the area of the head is at least ten times the cross-sectional area of the shank.

- The length of ISS – Shear Studs are selected to cover the maximum possible depth in the slab since potential shear cracks can develop at any location over the stud height.





Dimensions of ISS – Shear Studs



Sizes and Dimensions of ISS - Shear Studs (SI Units)			
Shank Diameter	**Head Diameter**	**Head Thickness**	**Head Cross-Sectional Area**
d (mm)	**D_h (mm)**	**t_h (mm)**	**A (mm^2)**
9.5	**30.2**	**5.3**	**716**
12.7	**40.4**	**7.1**	**1282**
15.9	**50.3**	**8.9**	**1987**
19.1	**60.5**	**10.7**	**2875**
25.4	**80.5**	**13.2**	**5090**

Sizes and Dimensions of ISS - Shear Studs (Imperial Units)			
Shank Diameter	**Head Diameter**	**Head Thickness**	**Head Cross-Sectional Area**
d (in)	**D_h (in)**	**t_h (in)**	**A (in^2)**
0.375	**1.19**	**0.21**	**1.1**
0.500	**1.59**	**0.28**	**2.0**
0.625	**1.98**	**0.35**	**3.1**
0.750	**2.38**	**0.42**	**4.4**
1.000	**3.17**	**0.52**	**7.9**

Acceptance Criteria of ISS - Shear Studs

- At periodic intervals, tensile tests of the ISS Shear Studs are performed as specified by INCONS quality assurance program in accordance with ASTM A370.

- The tensile tests are conducted in our factory and by a third party laboratory in order to ensure that our products always exceed the strictest international standards.

In all of the tested specimens:

- Failure occurs in ISS – Shear Stud material a minimum of one-half shank diameter from the head-to-shank connection as required by ASTM A1044.

- The tensile force at failure always exceeds the specified yield strength of ISS - Shear Stud material.

- No partial or total fracture of ISS – Shear Stud head is observed.

Design of ISS – Shear Studs

The design methodology for punching shear using ISS – Shear Studs is performed in accordance with ACI 318-14 and CSA A23.3-14.

The following illustrates the design procedure for a typical flat slab:

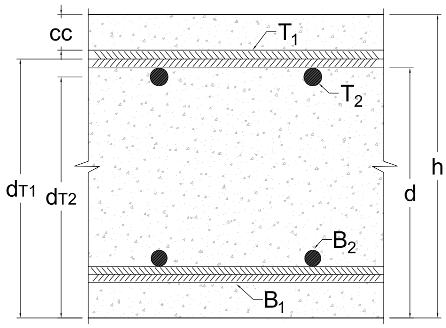
Formulas and Design Procedure:

1- **Inputs are:**

- Concrete Compressive Strength (f_c')
- Studs Yield Strength (f_y)
- Concrete Type Coefficient (λ)
- Slab Thickness (h)
- Concrete Cover (cc)
- Applied Shear Force (V_u)
- Applied Moment (M_u)

2- **Determine the effective depth of the slab.**

$$d = h - cc - \frac{D_{T1} + D_{T2}}{2}$$



Case Study:

- f_c' = 4000 psi
- f_y = 51 *ksi*
- λ = 1 (Normal Weight Concrete)
- h = 7 *in.*
- cc = 0.75 *in.*
- V_u = 110 *Kips*
- M_u = 600 *Kips.in*

$$d = 7 - 0.75 - \frac{0.625 + 0.625}{2} = 5.625\ in$$

Design of ISS – Shear Studs

3- Determine the location and geometry of the critical sections.

- The perimeter (b_o) of the critical section is chosen such that it minimizes the shear surface area at a distance of not less than ($d/2$) to edges or corners of columns.

- If an opening is located in the vicinity of the column, then a portion the critical section is considered ineffective as detailed in ACI 318-14.

- The critical shear perimeters for interior, edge and corner columns are shown in Figures 1, 2 and 3, respectively.

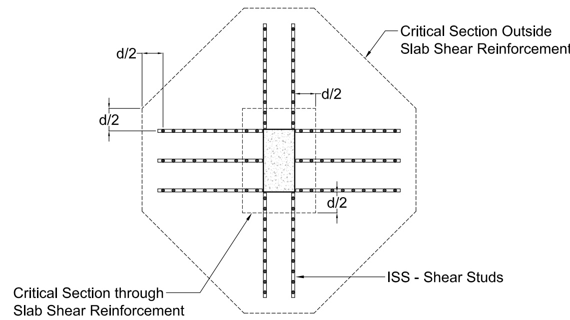


Fig. 1: Critical Perimeters for an Interior Column.

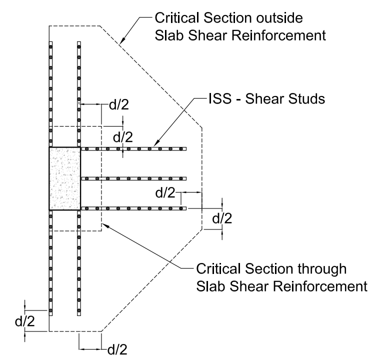


Fig. 2: Critical Perimeters for an Edge Column.

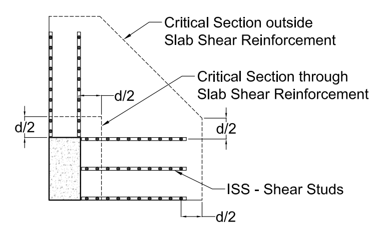


Fig. 3: Critical Perimeters for a Corner Column.

Design of ISS – Shear Studs

4- **Calculate the maximum factored shear stress (v_u) at the critical section.**

$$v_u = 295.0\ psi$$

5- **Calculate the nominal shear strength (v_n) at the critical section.**

$$v_n = \min \begin{cases} \left(2 + \frac{4}{\beta}\right) \lambda\sqrt{f_c'} \\ \left(\frac{\alpha_s d}{b_o} + 2\right) \lambda\sqrt{f_c'} \\ 4\lambda\sqrt{f_c'} \end{cases}$$

Where α_s and β are factors given in ACI 318-14 in terms of column location and geometrical properties, respectively.

$$\beta = \frac{Long\ Column\ Side}{Short\ Column\ Side} = \frac{20}{12} = 1.67$$

$$\alpha_s = 40 \text{ for interior columns}$$

$$v_n = \min \begin{cases} \left(2 + \frac{4}{1.67}\right) \lambda\sqrt{f_c'} = 4.4\lambda\sqrt{f_c'} \\ \left(\frac{40 \times 5.625}{86.5} + 2\right) \lambda\sqrt{f_c'} = 4.6\lambda\sqrt{f_c'} \\ 4\lambda\sqrt{f_c'} \end{cases}$$

$$\therefore v_n = 2.6\lambda\sqrt{f_c'} = 4 \times 1 \times \sqrt{4000} = 253\ psi$$

6- **Compare the maximum factored shear stress (v_u) to the nominal shear strength (v_n).**

- If $(v_u \leq \emptyset v_n)$, then no shear reinforcement or further check is required.
- If $\left(v_u \leq \emptyset \times 8\sqrt{f_c'}\right)$, then shear studs can be used to resist punching shear (Proceed to next step).
- If $\left(v_u > \emptyset \times 8\sqrt{f_c'}\right)$, then slab thickness is not sufficient and should be increased.

$$v_u = 295.0\ psi$$

$$\emptyset v_n = 0.75 \times 253 = 189.7\ psi$$

$$\because (v_u = 295.0\ psi) \leq (\emptyset v_n = 189.7\ psi)$$
$$\therefore \text{Concrete contribution is not sufficient}$$

$$\emptyset \times 8\sqrt{f_c'} = 0.75 \times 8 \times \sqrt{4000} = 379.4\ psi$$

$$\because (v_u = 295.0\ psi) \leq \left(\emptyset \times 8\sqrt{f_c'} = 379.4\ psi\right)$$
$$\therefore Shear\ studs\ can\ be\ used$$

Design of ISS – Shear Studs

7- Calculate the concrete contribution to shear strength (v_c) at the critical section.

$v_c = 3\lambda\sqrt{f_c'}$

$$v_c = 3\times 1\times\sqrt{4000} = 189.7\ psi$$

8- Calculate the shear stress (v_s) to be resisted by the shear studs.

$v_s = \frac{v_u}{\phi} - v_c$

$$v_s = \frac{295.0}{0.75} - 189.7 = 203.6\ psi$$

9- Select the spacing (s_o) between first peripheral line of shear studs and column face.

$0.35\ d \le (s_o)_{max} \le 0.50\ d$

$$0.35\ d = 0.35\times 5.625 = 1.97\ in$$

$$0.50\ d = 0.50\times 5.625 = 2.81\ in$$

$$\therefore Choose\ s_o = 2.25\ in$$

10- Select the spacing (s) between peripheral lines of shear studs.

- $s \le 0.75\ d$, $when\ v_u \le \emptyset\times 6\sqrt{f_c'}$
- $s \le 0.50\ d$, $when\ v_u > \emptyset\times 6\sqrt{f_c'}$

$$v_u = 295.0\ psi$$

$$\emptyset\times 6\sqrt{f_c'} = 0.75\times 6\times\sqrt{4000} = 284.6\ psi$$

$$\because (v_u = 295.0\ psi) > \left(\emptyset\times 6\sqrt{f_c'} = 284.6\ psi\right)$$
$$\therefore s \le (0.50\ d = 0.50\times 5.625 = 2.81\ in)$$

$$\therefore Choose\ s = 2.75\ in$$

11- Calculate the required shear stud area (A_v) for one peripheral line.

$A_v = \frac{v_s b_o s}{f_y}$

$$A_v = \frac{203.6\times 86.5\times 2.75}{51000} = 0.95\ in^2$$

Design of ISS – Shear Studs

12- Determine the minimum number of shear studs per peripheral line.

Select ISS studs of 0.11 in² cross-sectional area

$$N_{Studs} = \frac{A_v}{A_{stud}} = \frac{0.95}{0.11} = 8.64 \cong 9\ studs$$

13- Through trial and error, find the section where $v_u \leq \emptyset \times 2\sqrt{f'_c}$ which is located at a distance of (αd) from the face of the column.

<u>For First Trial:</u>
Assume critical section is located at 4.5d from column face.

$$\alpha = 4.5$$

$$\alpha d = 4.5 \times 5.625 = 25.3\ in$$

$$l_{x2} = c_x + 2s_o + 2(N_{Studs} - 1)s + d$$
$$l_{x2} = 12 + 2\times 2.25 + 2(9-1)\times 2.75 + 5.625$$
$$\therefore l_{x2} = 66.1\ in$$

$$l_{y2} = c_y + 2s_o + 2(N_{Studs} - 1)s + d$$
$$l_{y2} = 20 + 2\times 2.25 + 2(9-1)\times 2.75 + 5.625$$
$$\therefore l_{y2} = 74.1\ in$$

$$\gamma_{vy} = 1 - \frac{1}{1 + \frac{2}{3}\sqrt{l_{x2}/l_{y2}}} = 1 - \frac{1}{1 + \frac{2}{3}\sqrt{66.1/74.1}}$$
$$\therefore \gamma_{vy} = 0.386$$

$$b_o = 2(c_x + d) + 2(c_y + d) + 4[s_o + (N_{Studs} - 1)s]$$
$$b_o = 2(12 + 5.625) + 2(20 + 5.625) + 4[2.25 + (9-1)2.75]$$
$$\therefore b_o = 183.5\ in$$

$$A_c = b_o d = 183.5 \times 5.625 = 1032.1\ in^2$$

$$J_y = 547.3 \times 10^3\ in^4$$

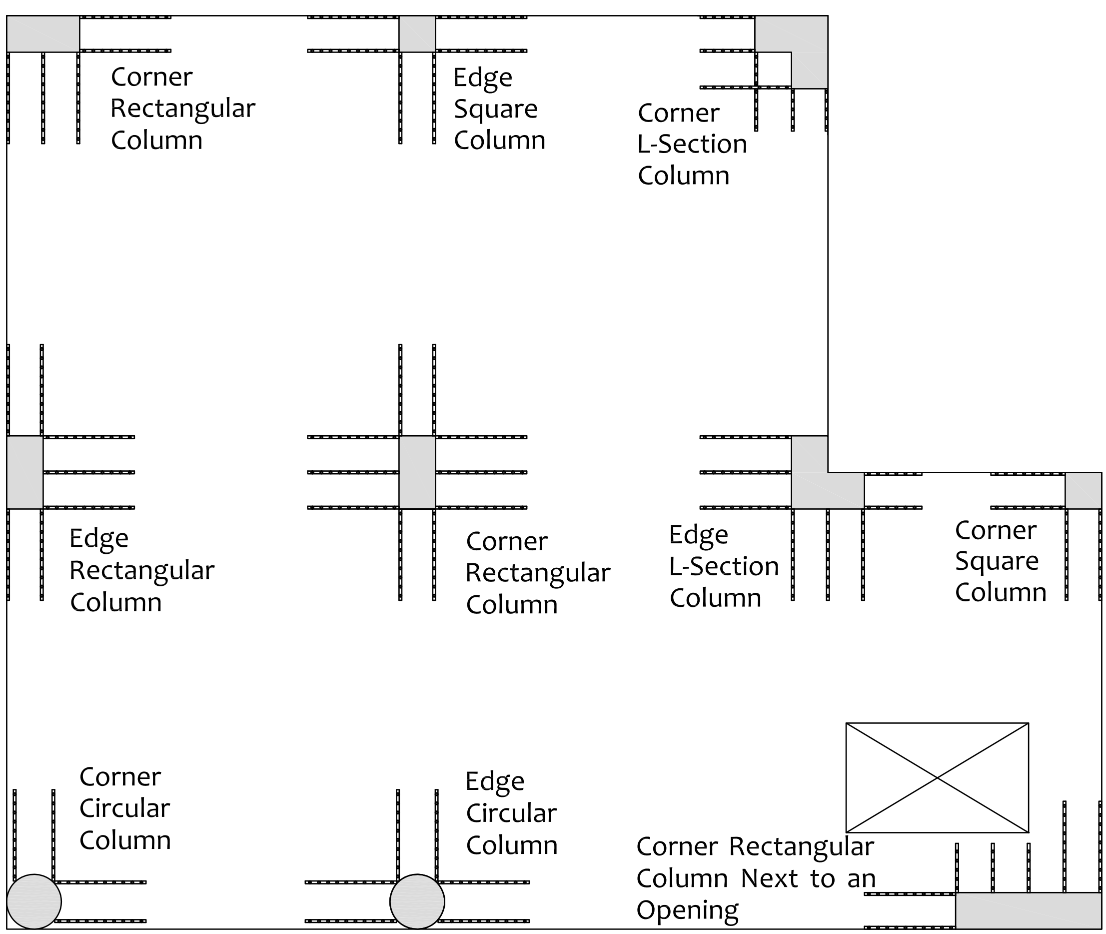
Design of ISS – Shear Studs

14- **Select the distance between the column face and the outermost peripheral line of shear studs to be greater than or equal to $\left(\alpha d - \frac{d}{2}\right)$.**

15- **The position of the critical section can be determined by selection of the number (n) of shear studs per line running in (x) or (y) direction.**

$$L_c = s_o + (n-1)s + \frac{d}{2}$$

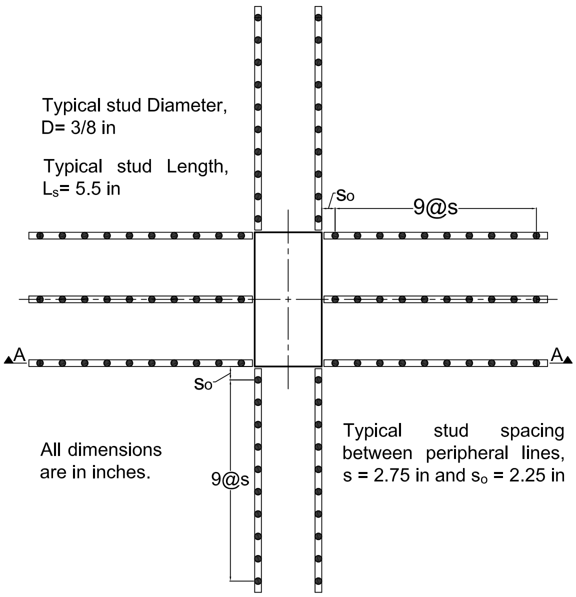
16- **Arrange the studs to satisfy ACI 318-14 requirements.**



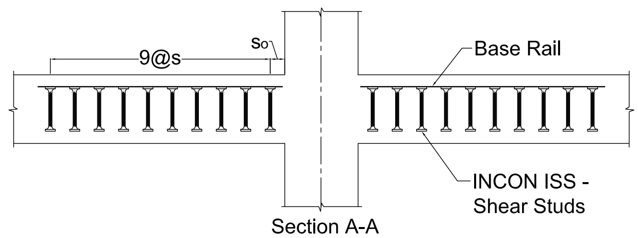
Typical Arrangement of ISS - Shear Studs

- Interior Rectangular Columns:

Plan View

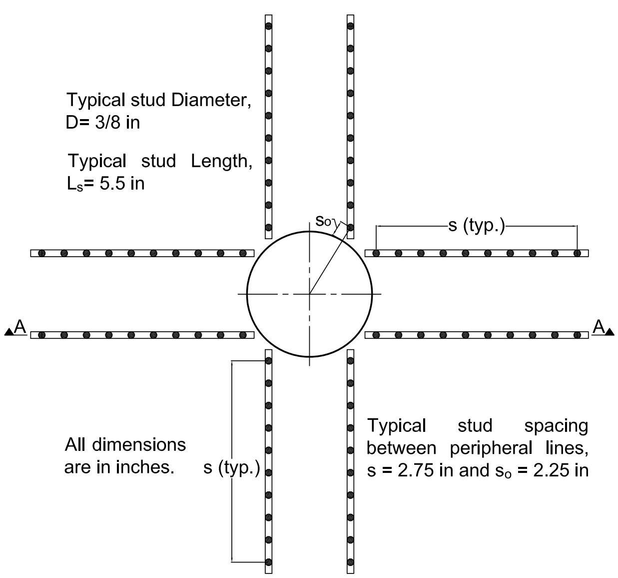


Elevation View

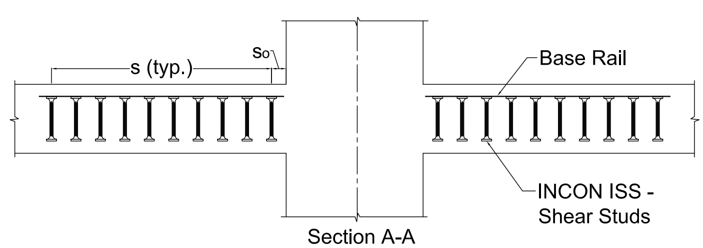


- Interior Circular Columns:

Plan View



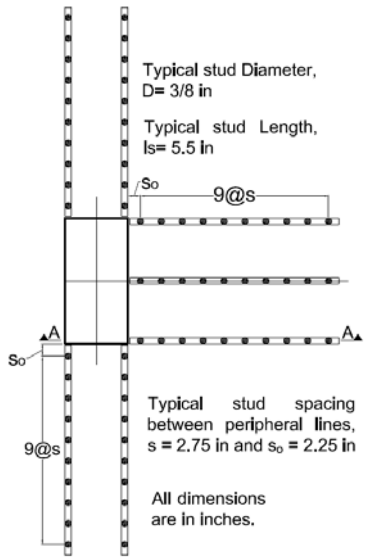
Elevation View



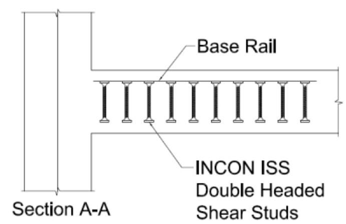
Typical Arrangement of ISS - Shear Studs

- Edge Rectangular Columns:

Plan View

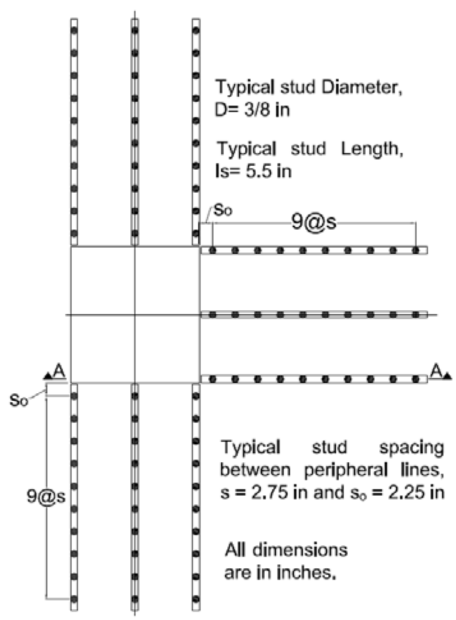


Elevation View

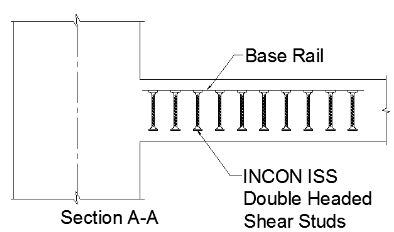


- Edge Square Columns:

Plan View



Elevation View



Designation of ISS – Shear Stud Assemblies

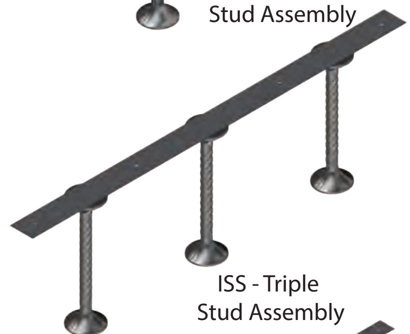
OPTION 1: Standard ISS-Stud Assemblies

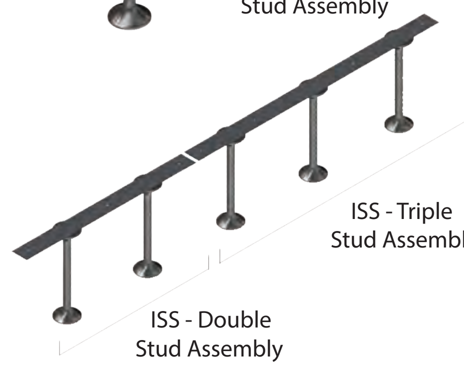
- Available as 2-stud or 3-stud assemblies.
- Several ISS 2-stud rails or ISS 3-stud rails can be combined to form a complete arm.

ISS	– 2	– 16	/ 225	– 320
Designation of Standard Stud Assembly	Number of Studs	Stud Diameter	Stud Length	Strip Length

ISS	– 3	– 16	/ 215	– 450
Designation of Standard Stud Assembly	Number of Studs	Stud Diameter	Stud Length	Strip Length

ISS	– 5	– 16	/ 255	– 780
Designation of Standard Stud Assembly	Number of Studs	Stud Diameter	Stud Length	Strip Length

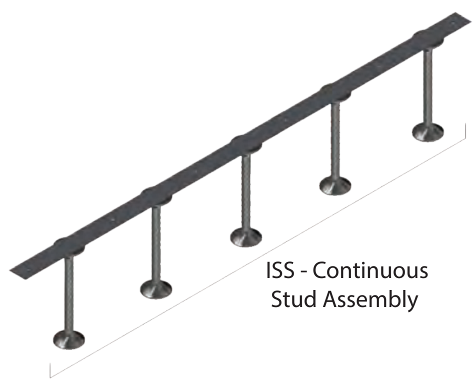




OPTION 2: Continuous ISS-Stud Assemblies

- Available on request up to a maximum of 10 shear studs per rail.

ISS(C)	– 5	– 16	/ 255	– 780
Designation of Continuous Stud Assembly	Number of Studs	Stud Diameter	Stud Length	Strip Length



Designation of ISS – Shear Studs

After designing the slab for punching shear, the following table can be used to determine different possible arrangements of ISS – Shear Studs per arm.

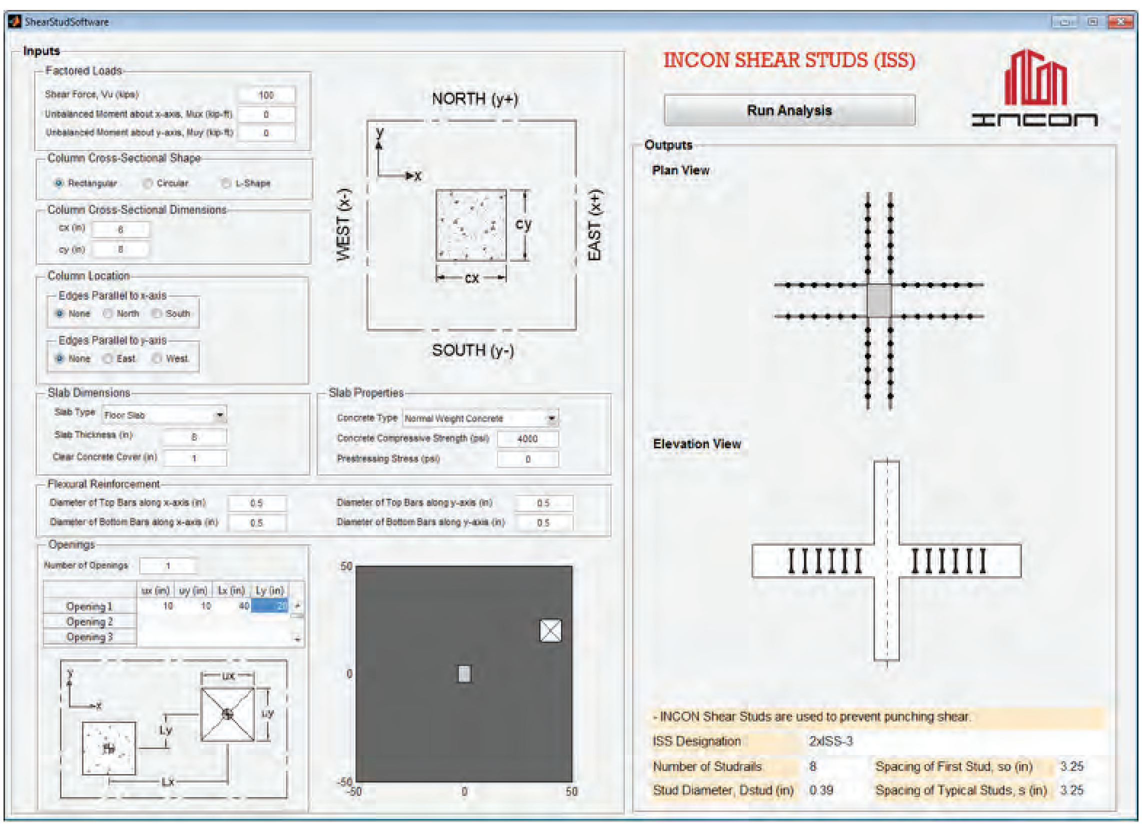
Number of ISS - Shear Studs per Arm	Alternative 1	Alternative 2	Alternative 3	Alternative 4
2	ISS-2	N.A.	N.A.	N.A.
3	ISS-3	N.A.	N.A.	N.A.
4	2 x ISS-2	ISS(C)-4	N.A.	N.A.
5	ISS-2 + ISS-3	ISS(C)-5	N.A.	N.A.
6	2 x ISS-3	3 x ISS-2	ISS(C)-6	N.A.
7	2 x ISS-2 + ISS-3	ISS(C)-7	ISS(C)-4 + ISS-3	N.A.
8	2 x ISS-3 + ISS-2	4 x ISS-2	ISS(C)-8	ISS(C)-5 + ISS-3
9	3 x ISS-3	3 x ISS-2 + ISS-3	ISS(C)-9	ISS(C)-5 + 2 x ISS-2
10	2 x ISS-2 + 2 x ISS-3	2 x ISS(C)-5	ISS(C)-10	2 x ISS(C)-4 + ISS-2
11	3 x ISS-3 + ISS-2	ISS(C)-9 + ISS-2	ISS(C)-8 + ISS-3	ISS(C)-7 + 2 x ISS-2
12	4 x ISS-3	6 x ISS-2	2 x ISS(C)-6	ISS(C)-10 + ISS-2
13	3 x ISS-3 + 2 x ISS-2	5 x ISS-2 + ISS-3	2 x ISS(C)-5 + ISS-3	ISS(C)-10 + ISS-3
14	4 x ISS-3 + ISS-2	7 x ISS-2	2 x ISS(C)-7	ISS(C)-10 + 2 x ISS-2
15	5 x ISS-3	6 x ISS-2 + ISS-3	3 x ISS(C)-5	ISS(C)-10 + ISS-3 + ISS-2
16	4 x ISS-3 + 2 x ISS-2	2 x ISS(C)-8	4 x ISS-4	ISS(C)-10 + 2 x ISS-3
17	5 x ISS-3 + ISS-2	2 x ISS(C)-7 + ISS-3	3 x ISS(C)-5 + ISS-2	ISS(C)-10 + ISS(C)-7
18	6 x ISS-3	3 x ISS(C)-5 + ISS-3	3 x ISS(C)-6	ISS(C)-10 + ISS(C)-8
19	5 x ISS-3 + 2 x ISS-2	3 x ISS(C)-5 + 2 x ISS-2	2 x ISS(C)-8 + ISS-3	ISS(C)-10 + ISS(C)-9
20	6 x ISS-3 + ISS-2	4 x ISS(C)-5	2 x ISS(C)-10	2 x ISS(C)-7 + 2 x ISS-3

How to Order?

- To ensure the most efficient and smooth construction flow, ASTM 1044-16 requires that the purchaser provide a detailed description of the required Shear Stud Assembly when placing the order.

- ISS Software simplifies this process by allowing the engineers to easily prepare schedules that summarize the quantity and geometrical properties of each ISS - Shear Stud Assembly at each column.

- As an alternative, engineers can specify required ISS – Stud Assembly using the tables on pages 25 through 30.



INCON Services

Design Services:

- Our design service enables us to accurately estimate project costs and speedily provide quotations.

- In addition to this service, INCON also provides design software for clients who prefer to produce their own calculations and layouts.

Delivery to Site:

- After preparing ISS - Shear Stud Assemblies, they will be packaged in containers clearly marked with the assembly part number and description to facilitate the installation process on site.

- The description provided on each package indicates the base rail width, thickness, length, and the number of headed studs with their diameter for each rail.

Installation of ISS – Shear Studs

When installing ISS – Shear Studs on site, the rails can be fitted as follows:

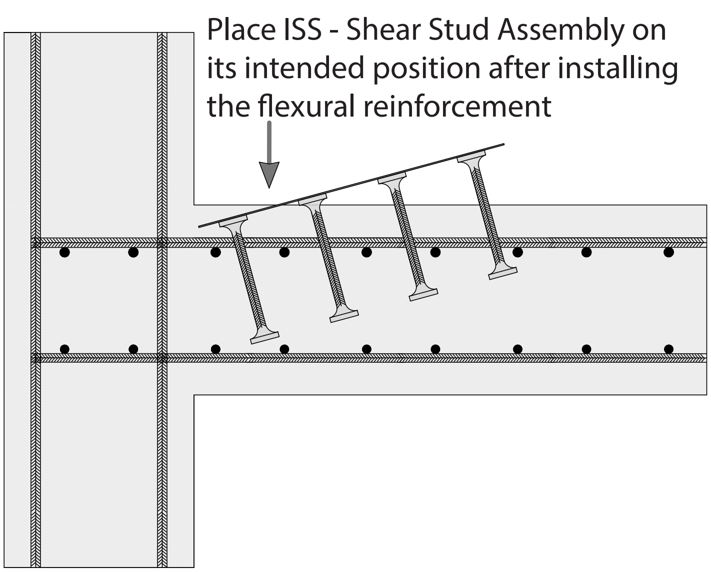
• Top down:

1- Install the upper and bottom layers of flexural reinforcement.

2- Place ISS – Shear Studs through the reinforcing bars according to the structural drawings.

3- Ensure that the base rail rests on the uppermost reinforcing bars either directly or indirectly using special ISS supporting plates. These plates can be provided separately on request.

4- Connect the base rail to the flexural reinforcing bars using tie wires.



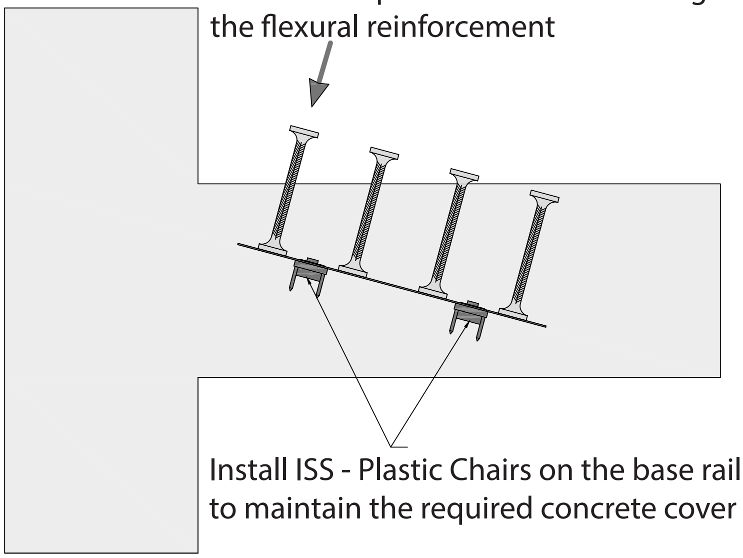
• Bottom up:

1- Attach ISS – Plastic Chairs on the base rail depending on the required clear concrete cover.

2- Place ISS – Stud Assembly on intended location to form shear arms in the slab around the columns.

3- Fix the Shear Studs to the formwork using an approved method by the engineering team.

4- Install the flexural reinforcement according to the structural drawings.



INCON Organizational Memberships

INCON is proudly an active member in the most prestigious organizations and committees throughout Canada and the United States.

Design Aids

The overall height and maximum spacing between ISS – Shear Studs can be determined using the tables detailed in pages 25 through 30 in terms of slab thickness, flexural reinforcement and clear concrete cover.

Page 25	Actual Overall Height of ISS – Shear Studs according to Canadian Standards.
Page 26	Actual Overall Height of ISS – Shear Studs according to American Standards.
Page 27	Actual Overall Height of ISS – Shear Studs according to European and the Middle Eastern Standards.
Page 28	Maximum Spacing of ISS – Shear Studs according to Canadian Standards.
Page 29	Maximum Spacing of ISS – Shear Studs according to American Standards.
Page 30	Maximum Spacing of ISS – Shear Studs according to European and the Middle Eastern Standards.

The Following Table Can be used to Determine the Actual Overall Height of ISS-Shear Studs:

CANADA

Flexural Bar Designation	10M			15M			20M			25M			30M			35M			45M		
Clear Concrete Cover (mm) / Slab Thickness (mm)	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75
120	74	54	N.A.	72	52	N.A.	70	50	N.A.	67	47	N.A.	65	45	N.A.	62	42	N.A.	58	38	N.A.
150	104	84	N.A.	102	82	N.A.	100	80	N.A.	97	77	N.A.	95	75	N.A.	92	72	N.A.	88	68	N.A.
180	134	114	N.A.	132	112	N.A.	130	110	N.A.	127	107	N.A.	125	105	N.A.	122	102	N.A.	118	98	N.A.
200	154	134	44	152	132	42	150	130	40	147	127	37	145	125	35	142	122	32	138	118	28
225	179	159	69	177	157	67	175	155	65	172	152	62	170	150	60	167	147	57	163	143	53
250	204	184	94	202	182	92	200	180	90	197	177	87	195	175	85	192	172	82	188	168	78
275	229	209	119	227	207	117	225	205	115	222	202	112	220	200	110	217	197	107	213	193	103
300	254	234	144	252	232	142	250	230	140	247	227	137	245	225	135	242	222	132	238	218	128
325	279	259	169	277	257	167	275	255	165	272	252	162	270	250	160	267	247	157	263	243	153
350	304	284	194	302	282	192	300	280	190	297	277	187	295	275	185	292	272	182	288	268	178
375	329	309	219	327	307	217	325	305	215	322	302	212	320	300	210	317	297	207	313	293	203
400	354	334	244	352	332	242	350	330	240	347	327	237	345	325	235	342	322	232	338	318	228
425	379	359	269	377	357	267	375	355	265	372	352	262	370	350	260	367	347	257	363	343	253
450	404	384	294	402	382	292	400	380	290	397	377	287	395	375	285	392	372	282	388	368	278
475	429	409	319	427	407	317	425	405	315	422	402	312	420	400	310	417	397	307	413	393	303
500	454	434	344	452	432	342	450	430	340	447	427	337	445	425	335	442	422	332	438	418	328
525	479	459	369	477	457	367	475	455	365	472	452	362	470	450	360	467	447	357	463	443	353
550	504	484	394	502	482	392	500	480	390	497	477	387	495	475	385	492	472	382	488	468	378
575	529	509	419	527	507	417	525	505	415	522	502	412	520	500	410	517	497	407	513	493	403
600	554	534	444	552	532	442	550	530	440	547	527	437	545	525	435	542	522	432	538	518	428
625	579	559	469	577	557	467	575	555	465	572	552	462	570	550	460	567	547	457	563	543	453
650	604	584	494	602	582	492	600	580	490	597	577	487	595	575	485	592	572	482	588	568	478
675	629	609	519	627	607	517	625	605	515	622	602	512	620	600	510	617	597	507	613	593	503
700	654	634	544	652	632	542	650	630	540	647	627	537	645	625	535	642	622	532	638	618	528
750	704	684	594	702	682	592	700	680	590	697	677	587	695	675	585	692	672	582	688	668	578
800	754	734	644	752	732	642	750	730	640	747	727	637	745	725	635	742	722	632	738	718	628
850	804	784	694	802	782	692	800	780	690	797	777	687	795	775	685	792	772	682	788	768	678
900	854	834	744	852	832	742	850	830	740	847	827	737	845	825	735	842	822	732	838	818	728
950	904	884	794	902	882	792	900	880	790	897	877	787	895	875	785	892	872	782	888	868	778
1000	954	934	844	952	932	842	950	930	840	947	927	837	945	925	835	942	922	832	938	918	828
1050	1004	984	894	1002	982	892	1000	980	890	997	977	887	995	975	885	992	972	882	988	968	878
1100	1054	1034	944	1052	1032	942	1050	1030	940	1047	1027	937	1045	1025	935	1042	1022	932	1038	1018	928
1150	1104	1084	994	1102	1082	992	1100	1080	990	1097	1077	987	1095	1075	985	1092	1072	982	1088	1068	978
1200	1154	1134	1044	1152	1132	1042	1150	1130	1040	1147	1127	1037	1145	1125	1035	1142	1122	1032	1138	1118	1028

The Following Table Can be used to Determine the Actual Overall Height of ISS-Shear Studs:

USA

Flexural Bar Designation		#3			#4			#5			#6			#7			#8			#9			#10		
Clear Concrete Cover (in.)		1.5	2	3	1.5	2	3	1.5	2	3	1.5	2	3	1.5	2	3	1.5	2	3	1.5	2	3	1.5	2	3
Slab Thickness (in.)	5	1.8	N.A.	N.A.	1.8	N.A.	N.A.	1.7	N.A.	N.A.	1.6	N.A.	N.A.	1.6	N.A.	N.A.	1.5	N.A.	N.A.	1.4	N.A.	N.A.	1.4	N.A.	N.A.
	6	2.8	1.8	N.A.	2.8	1.8	N.A.	2.7	1.7	N.A.	2.6	1.6	N.A.	2.6	1.6	N.A.	2.5	1.5	N.A.	2.4	1.4	N.A.	2.4	1.4	N.A.
	7	3.8	2.8	N.A.	3.8	2.8	N.A.	3.7	2.7	N.A.	3.6	2.6	N.A.	3.6	2.6	N.A.	3.5	2.5	N.A.	3.4	2.4	N.A.	3.4	2.4	N.A.
	8	4.8	3.8	1.8	4.8	3.8	1.8	4.7	3.7	1.7	4.6	3.6	1.6	4.6	3.6	1.6	4.5	3.5	1.5	4.4	3.4	1.4	4.4	3.4	1.4
	9	5.8	4.8	2.8	5.8	4.8	2.8	5.7	4.7	2.7	5.6	4.6	2.6	5.6	4.6	2.6	5.5	4.5	2.5	5.4	4.4	2.4	5.4	4.4	2.4
	10	6.8	5.8	3.8	6.8	5.8	3.8	6.7	5.7	3.7	6.6	5.6	3.6	6.6	5.6	3.6	6.5	5.5	3.5	6.4	5.4	3.4	6.4	5.4	3.4
	11	7.8	6.8	4.8	7.8	6.8	4.8	7.7	6.7	4.7	7.6	6.6	4.6	7.6	6.6	4.6	7.5	6.5	4.5	7.4	6.4	4.4	7.4	6.4	4.4
	12	8.8	7.8	5.8	8.8	7.8	5.8	8.7	7.7	5.7	8.6	7.6	5.6	8.6	7.6	5.6	8.5	7.5	5.5	8.4	7.4	5.4	8.4	7.4	5.4
	13	9.8	8.8	6.8	9.8	8.8	6.8	9.7	8.7	6.7	9.6	8.6	6.6	9.6	8.6	6.6	9.5	8.5	6.5	9.4	8.4	6.4	9.4	8.4	6.4
	14	10.8	9.8	7.8	10.8	9.8	7.8	10.7	9.7	7.7	10.6	9.6	7.6	10.6	9.6	7.6	10.5	9.5	7.5	10.4	9.4	7.4	10.4	9.4	7.4
	15	11.8	10.8	8.8	11.8	10.8	8.8	11.7	10.7	8.7	11.6	10.6	8.6	11.6	10.6	8.6	11.5	10.5	8.5	11.4	10.4	8.4	11.4	10.4	8.4
	16	12.8	11.8	9.8	12.8	11.8	9.8	12.7	11.7	9.7	12.6	11.6	9.6	12.6	11.6	9.6	12.5	11.5	9.5	12.4	11.4	9.4	12.4	11.4	9.4
	17	13.8	12.8	10.8	13.8	12.8	10.8	13.7	12.7	10.7	13.6	12.6	10.6	13.6	12.6	10.6	13.5	12.5	10.5	13.4	12.4	10.4	13.4	12.4	10.4
	18	14.8	13.8	11.8	14.8	13.8	11.8	14.7	13.7	11.7	14.6	13.6	11.6	14.6	13.6	11.6	14.5	13.5	11.5	14.4	13.4	11.4	14.4	13.4	11.4
	19	15.8	14.8	12.8	15.8	14.8	12.8	15.7	14.7	12.7	15.6	14.6	12.6	15.6	14.6	12.6	15.5	14.5	12.5	15.4	14.4	12.4	15.4	14.4	12.4
	20	16.8	15.8	13.8	16.8	15.8	13.8	16.7	15.7	13.7	16.6	15.6	13.6	16.6	15.6	13.6	16.5	15.5	13.5	16.4	15.4	13.4	16.4	15.4	13.4
	21	17.8	16.8	14.8	17.8	16.8	14.8	17.7	16.7	14.7	17.6	16.6	14.6	17.6	16.6	14.6	17.5	16.5	14.5	17.4	16.4	14.4	17.4	16.4	14.4
	22	18.8	17.8	15.8	18.8	17.8	15.8	18.7	17.7	15.7	18.6	17.6	15.6	18.6	17.6	15.6	18.5	17.5	15.5	18.4	17.4	15.4	18.4	17.4	15.4
	23	19.8	18.8	16.8	19.8	18.8	16.8	19.7	18.7	16.7	19.6	18.6	16.6	19.6	18.6	16.6	19.5	18.5	16.5	19.4	18.4	16.4	19.4	18.4	16.4
	24	20.8	19.8	17.8	20.8	19.8	17.8	20.7	19.7	17.7	20.6	19.6	17.6	20.6	19.6	17.6	20.5	19.5	17.5	20.4	19.4	17.4	20.4	19.4	17.4
	25	21.8	20.8	18.8	21.8	20.8	18.8	21.7	20.7	18.7	21.6	20.6	18.6	21.6	20.6	18.6	21.5	20.5	18.5	21.4	20.4	18.4	21.4	20.4	18.4
	26	22.8	21.8	19.8	22.8	21.8	19.8	22.7	21.7	19.7	22.6	21.6	19.6	22.6	21.6	19.6	22.5	21.5	19.5	22.4	21.4	19.4	22.4	21.4	19.4
	27	23.8	22.8	20.8	23.8	22.8	20.8	23.7	22.7	20.7	23.6	22.6	20.6	23.6	22.6	20.6	23.5	22.5	20.5	23.4	22.4	20.4	23.4	22.4	20.4
	28	24.8	23.8	21.8	24.8	23.8	21.8	24.7	23.7	21.7	24.6	23.6	21.6	24.6	23.6	21.6	24.5	23.5	21.5	24.4	23.4	21.4	24.4	23.4	21.4
	29	25.8	24.8	22.8	25.8	24.8	22.8	25.7	24.7	22.7	25.6	24.6	22.6	25.6	24.6	22.6	25.5	24.5	22.5	25.4	24.4	22.4	25.4	24.4	22.4
	30	26.8	25.8	23.8	26.8	25.8	23.8	26.7	25.7	23.7	26.6	25.6	23.6	26.6	25.6	23.6	26.5	25.5	23.5	26.4	25.4	23.4	26.4	25.4	23.4
	31	27.8	26.8	24.8	27.8	26.8	24.8	27.7	26.7	24.7	27.6	26.6	24.6	27.6	26.6	24.6	27.5	26.5	24.5	27.4	26.4	24.4	27.4	26.4	24.4
	32	28.8	27.8	25.8	28.8	27.8	25.8	28.7	27.7	25.7	28.6	27.6	25.6	28.6	27.6	25.6	28.5	27.5	25.5	28.4	27.4	25.4	28.4	27.4	25.4
	33	29.8	28.8	26.8	29.8	28.8	26.8	29.7	28.7	26.7	29.6	28.6	26.6	29.6	28.6	26.6	29.5	28.5	26.5	29.4	28.4	26.4	29.4	28.4	26.4
	34	30.8	29.8	27.8	30.8	29.8	27.8	30.7	29.7	27.7	30.6	29.6	27.6	30.6	29.6	27.6	30.5	29.5	27.5	30.4	29.4	27.4	30.4	29.4	27.4
	35	31.8	30.8	28.8	31.8	30.8	28.8	31.7	30.7	28.7	31.6	30.6	28.6	31.6	30.6	28.6	31.5	30.5	28.5	31.4	30.4	28.4	31.4	30.4	28.4
	36	32.8	31.8	29.8	32.8	31.8	29.8	32.7	31.7	29.7	32.6	31.6	29.6	32.6	31.6	29.6	32.5	31.5	29.5	32.4	31.4	29.4	32.4	31.4	29.4
	37	33.8	32.8	30.8	33.8	32.8	30.8	33.7	32.7	30.7	33.6	32.6	30.6	33.6	32.6	30.6	33.5	32.5	30.5	33.4	32.4	30.4	33.4	32.4	30.4
	38	34.8	33.8	31.8	34.8	33.8	31.8	34.7	33.7	31.7	34.6	33.6	31.6	34.6	33.6	31.6	34.5	33.5	31.5	34.4	33.4	31.4	34.4	33.4	31.4
	39	35.8	34.8	32.8	35.8	34.8	32.8	35.7	34.7	32.7	35.6	34.6	32.6	35.6	34.6	32.6	35.5	34.5	32.5	35.4	34.4	32.4	35.4	34.4	32.4
	40	36.8	35.8	33.8	36.8	35.8	33.8	36.7	35.7	33.7	36.6	35.6	33.6	36.6	35.6	33.6	36.5	35.5	33.5	36.4	35.4	33.4	36.4	35.4	33.4
	41	37.8	36.8	34.8	37.8	36.8	34.8	37.7	36.7	34.7	37.6	36.6	34.6	37.6	36.6	34.6	37.5	36.5	34.5	37.4	36.4	34.4	37.4	36.4	34.4
	42	38.8	37.8	35.8	38.8	37.8	35.8	38.7	37.7	35.7	38.6	37.6	35.6	38.6	37.6	35.6	38.5	37.5	35.5	38.4	37.4	35.4	38.4	37.4	35.4
	43	39.8	38.8	36.8	39.8	38.8	36.8	39.7	38.7	36.7	39.6	38.6	36.6	39.6	38.6	36.6	39.5	38.5	36.5	39.4	38.4	36.4	39.4	38.4	36.4
	44	40.8	39.8	37.8	40.8	39.8	37.8	40.7	39.7	37.7	40.6	39.6	37.6	40.6	39.6	37.6	40.5	39.5	37.5	40.4	39.4	37.4	40.4	39.4	37.4
	45	41.8	40.8	38.8	41.8	40.8	38.8	41.7	40.7	38.7	41.6	40.6	38.6	41.6	40.6	38.6	41.5	40.5	38.5	41.4	40.4	38.4	41.4	40.4	38.4
	46	42.8	41.8	39.8	42.8	41.8	39.8	42.7	41.7	39.7	42.6	41.6	39.6	42.6	41.6	39.6	42.5	41.5	39.5	42.4	41.4	39.4	42.4	41.4	39.4
	47	43.8	42.8	40.8	43.8	42.8	40.8	43.7	42.7	40.7	43.6	42.6	40.6	43.6	42.6	40.6	43.5	42.5	40.5	43.4	42.4	40.4	43.4	42.4	40.4

The Following Table Can be used to Determine the Actual Overall Height of ISS-Shear Studs:

Europe and Middle East

Flexural Bar Designation	10,0			12,0			14,0			16,0			20,0			25,0			28,0			32,0			40,0		
Clear Concrete Cover (mm) / Slab Thickness (mm)	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75
120	75	55	N.A.	74	54	N.A.	73	53	N.A.	72	52	N.A.	70	50	N.A.	68	48	N.A.	66	46	N.A.	64	44	N.A.	60	40	N.A.
150	105	85	N.A.	104	84	N.A.	103	83	N.A.	102	82	N.A.	100	80	N.A.	98	78	N.A.	96	76	N.A.	94	74	N.A.	90	70	N.A.
180	135	115	25	134	114	N.A.	133	113	N.A.	132	112	N.A.	130	110	N.A.	128	108	N.A.	126	106	N.A.	124	104	N.A.	120	100	N.A.
200	155	135	45	154	134	44	153	133	43	152	132	42	150	130	40	148	128	38	146	126	36	144	124	34	140	120	30
225	180	160	70	179	159	69	178	158	68	177	157	67	175	155	65	173	153	63	171	151	61	169	149	59	165	145	55
250	205	185	95	204	184	94	203	183	93	202	182	92	200	180	90	198	178	88	196	176	86	194	174	84	190	170	80
275	230	210	120	229	209	119	228	208	118	227	207	117	225	205	115	223	203	113	221	201	111	219	199	109	215	195	105
300	255	235	145	254	234	144	253	233	143	252	232	142	250	230	140	248	228	138	246	226	136	244	224	134	240	220	130
325	280	260	170	279	259	169	278	258	168	277	257	167	275	255	165	273	253	163	271	251	161	269	249	159	265	245	155
350	305	285	195	304	284	194	303	283	193	302	282	192	300	280	190	298	278	188	296	276	186	294	274	184	290	270	180
375	330	310	220	329	309	219	328	308	218	327	307	217	325	305	215	323	303	213	321	301	211	319	299	209	315	295	205
400	355	335	245	354	334	244	353	333	243	352	332	242	350	330	240	348	328	238	346	326	236	344	324	234	340	320	230
425	380	360	270	379	359	269	378	358	268	377	357	267	375	355	265	373	353	263	371	351	261	369	349	259	365	345	255
450	405	385	295	404	384	294	403	383	293	402	382	292	400	380	290	398	378	288	396	376	286	394	374	284	390	370	280
475	430	410	320	429	409	319	428	408	318	427	407	317	425	405	315	423	403	313	421	401	311	419	399	309	415	395	305
500	455	435	345	454	434	344	453	433	343	452	432	342	450	430	340	448	428	338	446	426	336	444	424	334	440	420	330
525	480	460	370	479	459	369	478	458	368	477	457	367	475	455	365	473	453	363	471	451	361	469	449	359	465	445	355
550	505	485	395	504	484	394	503	483	393	502	482	392	500	480	390	498	478	388	496	476	386	494	474	384	490	470	380
575	530	510	420	529	509	419	528	508	418	527	507	417	525	505	415	523	503	413	521	501	411	519	499	409	515	495	405
600	555	535	445	554	534	444	553	533	443	552	532	442	550	530	440	548	528	438	546	526	436	544	524	434	540	520	430
625	580	560	470	579	559	469	578	558	468	577	557	467	575	555	465	573	553	463	571	551	461	569	549	459	565	545	455
650	605	585	495	604	584	494	603	583	493	602	582	492	600	580	490	598	578	488	596	576	486	594	574	484	590	570	480
675	630	610	520	629	609	519	628	608	518	627	607	517	625	605	515	623	603	513	621	601	511	619	599	509	615	595	505
700	655	635	545	654	634	544	653	633	543	652	632	542	650	630	540	648	628	538	646	626	536	644	624	534	640	620	530
750	705	685	595	704	684	594	703	683	593	702	682	592	700	680	590	698	678	588	696	676	586	694	674	584	690	670	580
800	755	735	645	754	734	644	753	733	643	752	732	642	750	730	640	748	728	638	746	726	636	744	724	634	740	720	630
850	805	785	695	804	784	694	803	783	693	802	782	692	800	780	690	798	778	688	796	776	686	794	774	684	790	770	680
900	855	835	745	854	834	744	853	833	743	852	832	742	850	830	740	848	828	738	846	826	736	844	824	734	840	820	730
950	905	885	795	904	884	794	903	883	793	902	882	792	900	880	790	898	878	788	896	876	786	894	874	784	890	870	780
1000	955	935	845	954	934	844	953	933	843	952	932	842	950	930	840	948	928	838	946	926	836	944	924	834	940	920	830
1050	1005	985	895	1004	984	894	1003	983	893	1002	982	892	1000	980	890	998	978	888	996	976	886	994	974	884	990	970	880
1100	1055	1035	945	1054	1034	944	1053	1033	943	1052	1032	942	1050	1030	940	1048	1028	938	1046	1026	936	1044	1024	934	1040	1020	930
1150	1105	1085	995	1104	1084	994	1103	1083	993	1102	1082	992	1100	1080	990	1098	1078	988	1096	1076	986	1094	1074	984	1090	1070	980
1200	1155	1135	1045	1154	1134	1044	1153	1133	1043	1152	1132	1042	1150	1130	1040	1148	1128	1038	1146	1126	1036	1144	1124	1034	1140	1120	1030

The Following Table Can be used to Determine the Maximum Spacing between ISS-Shear Studs:

CANADA

Flexural Bar Designation		10M			15M			20M			25M			30M			35M			45M		
Clear Concrete Cover (mm)		20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75
Slab Thickness (mm)	120	44	39	N.A.	42	37	N.A.	40	35	N.A.	37	32	N.A.	35	30	N.A.	32	27	N.A.	28	23	N.A.
	150	59	54	N.A.	57	52	N.A.	55	50	N.A.	52	47	N.A.	50	45	N.A.	47	42	N.A.	43	38	N.A.
	180	74	69	N.A.	72	67	N.A.	70	65	N.A.	67	62	N.A.	65	60	N.A.	62	57	N.A.	58	53	N.A.
	200	84	79	57	82	77	55	80	75	53	77	72	50	75	70	48	72	67	45	68	63	41
	225	97	92	69	95	90	67	93	88	65	90	85	62	88	83	60	85	80	57	81	76	53
	250	109	104	82	107	102	80	105	100	78	102	97	75	100	95	73	97	92	70	93	88	66
	275	122	117	94	120	115	92	118	113	90	115	110	87	113	108	85	110	105	82	106	101	78
	300	134	129	107	132	127	105	130	125	103	127	122	100	125	120	98	122	117	95	118	113	91
	325	147	142	119	145	140	117	143	138	115	140	135	112	138	133	110	135	130	107	131	126	103
	350	159	154	132	157	152	130	155	150	128	152	147	125	150	145	123	147	142	120	143	138	116
	375	172	167	144	170	165	142	168	163	140	165	160	137	163	158	135	160	155	132	156	151	128
	400	184	179	157	182	177	155	180	175	153	177	172	150	175	170	148	172	167	145	168	163	141
	425	197	192	169	195	190	167	193	188	165	190	185	162	188	183	160	185	180	157	181	176	153
	450	209	204	182	207	202	180	205	200	178	202	197	175	200	195	173	197	192	170	193	188	166
	475	222	217	194	220	215	192	218	213	190	215	210	187	213	208	185	210	205	182	206	201	178
	500	234	229	207	232	227	205	230	225	203	227	222	200	225	220	198	222	217	195	218	213	191
	525	247	242	219	245	240	217	243	238	215	240	235	212	238	233	210	235	230	207	231	226	203
	550	259	254	232	257	252	230	255	250	228	252	247	225	250	245	223	247	242	220	243	238	216
	575	272	267	244	270	265	242	268	263	240	265	260	237	263	258	235	260	255	232	256	251	228
	600	284	279	257	282	277	255	280	275	253	277	272	250	275	270	248	272	267	245	268	263	241
	625	297	292	269	295	290	267	293	288	265	290	285	262	288	283	260	285	280	257	281	276	253
	650	309	304	282	307	302	280	305	300	278	302	297	275	300	295	273	297	292	270	293	288	266
	675	322	317	294	320	315	292	318	313	290	315	310	287	313	308	285	310	305	282	306	301	278
	700	334	329	307	332	327	305	330	325	303	327	322	300	325	320	298	322	317	295	318	313	291
	750	359	354	332	357	352	330	355	350	328	352	347	325	350	345	323	347	342	320	343	338	316
	800	384	379	357	382	377	355	380	375	353	377	372	350	375	370	348	372	367	345	368	363	341
	850	409	404	382	407	402	380	405	400	378	402	397	375	400	395	373	397	392	370	393	388	366
	900	434	429	407	432	427	405	430	425	403	427	422	400	425	420	398	422	417	395	418	413	391
	950	459	454	432	457	452	430	455	450	428	452	447	425	450	445	423	447	442	420	443	438	416
	1000	484	479	457	482	477	455	480	475	453	477	472	450	475	470	448	472	467	445	468	463	441
	1050	509	504	482	507	502	480	505	500	478	502	497	475	500	495	473	497	492	470	493	488	466
	1100	534	529	507	532	527	505	530	525	503	527	522	500	525	520	498	522	517	495	518	513	491
	1150	559	554	532	557	552	530	555	550	528	552	547	525	550	545	523	547	542	520	543	538	516
	1200	584	579	557	582	577	555	580	575	553	577	572	550	575	570	548	572	567	545	568	563	541

The Following Table Can be used to Determine the Maximum Spacing between ISS-Shear Studs:

USA

Flexural Bar Designation		#3			#4			#5			#6			#7			#8			#9			#10		
Clear Concrete Cover (in.)		1.5	2.0	3.0	1.5	2.0	3.0	1.5	2.0	3.0	1.5	2.0	3.0	1.5	2.0	3.0	1.5	2.0	3.0	1.5	2.0	3.0	1.5	2.0	3.0
Slab Thickness (in.)	5	1.6	N.A.	N.A.	1.5	N.A.	N.A.	1.4	N.A.	N.A.	1.4	N.A.	N.A.	1.3	N.A.	N.A.	1.3	N.A.	N.A.	1.2	N.A.	N.A.	1.1	N.A.	N.A.
	6	2.1	1.8	N.A.	2.0	1.8	N.A.	1.9	1.7	N.A.	1.9	1.6	N.A.	1.8	1.6	N.A.	1.8	1.5	N.A.	1.7	1.4	N.A.	1.6	1.4	N.A.
	7	2.6	2.3	N.A.	2.5	2.3	N.A.	2.4	2.2	N.A.	2.4	2.1	N.A.	2.3	2.1	N.A.	2.3	2.0	N.A.	2.2	1.9	N.A.	2.1	1.9	N.A.
	8	3.1	2.8	2.3	3.0	2.8	2.3	2.9	2.7	2.2	2.9	2.6	2.1	2.8	2.6	2.1	2.8	2.5	2.0	2.7	2.4	1.9	2.6	2.4	1.9
	9	3.6	3.3	2.8	3.5	3.3	2.8	3.4	3.2	2.7	3.4	3.1	2.6	3.3	3.1	2.6	3.3	3.0	2.5	3.2	2.9	2.4	3.1	2.9	2.4
	10	4.1	3.8	3.3	4.0	3.8	3.3	3.9	3.7	3.2	3.9	3.6	3.1	3.8	3.6	3.1	3.8	3.5	3.0	3.7	3.4	2.9	3.6	3.4	2.9
	11	4.6	4.3	3.8	4.5	4.3	3.8	4.4	4.2	3.7	4.4	4.1	3.6	4.3	4.1	3.6	4.3	4.0	3.5	4.2	3.9	3.4	4.1	3.9	3.4
	12	5.1	4.8	4.3	5.0	4.8	4.3	4.9	4.7	4.2	4.9	4.6	4.1	4.8	4.6	4.1	4.8	4.5	4.0	4.7	4.4	3.9	4.6	4.4	3.9
	13	5.6	5.3	4.8	5.5	5.3	4.8	5.4	5.2	4.7	5.4	5.1	4.6	5.3	5.1	4.6	5.3	5.0	4.5	5.2	4.9	4.4	5.1	4.9	4.4
	14	6.1	5.8	5.3	6.0	5.8	5.3	5.9	5.7	5.2	5.9	5.6	5.1	5.8	5.6	5.1	5.8	5.5	5.0	5.7	5.4	4.9	5.6	5.4	4.9
	15	6.6	6.3	5.8	6.5	6.3	5.8	6.4	6.2	5.7	6.4	6.1	5.6	6.3	6.1	5.6	6.3	6.0	5.5	6.2	5.9	5.4	6.1	5.9	5.4
	16	7.1	6.8	6.3	7.0	6.8	6.3	6.9	6.7	6.2	6.9	6.6	6.1	6.8	6.6	6.1	6.8	6.5	6.0	6.7	6.4	5.9	6.6	6.4	5.9
	17	7.6	7.3	6.8	7.5	7.3	6.8	7.4	7.2	6.7	7.4	7.1	6.6	7.3	7.1	6.6	7.3	7.0	6.5	7.2	6.9	6.4	7.1	6.9	6.4
	18	8.1	7.8	7.3	8.0	7.8	7.3	7.9	7.7	7.2	7.9	7.6	7.1	7.8	7.6	7.1	7.8	7.5	7.0	7.7	7.4	6.9	7.6	7.4	6.9
	19	8.6	8.3	7.8	8.5	8.3	7.8	8.4	8.2	7.7	8.4	8.1	7.6	8.3	8.1	7.6	8.3	8.0	7.5	8.2	7.9	7.4	8.1	7.9	7.4
	20	9.1	8.8	8.3	9.0	8.8	8.3	8.9	8.7	8.2	8.9	8.6	8.1	8.8	8.6	8.1	8.8	8.5	8.0	8.7	8.4	7.9	8.6	8.4	7.9
	21	9.6	9.3	8.8	9.5	9.3	8.8	9.4	9.2	8.7	9.4	9.1	8.6	9.3	9.1	8.6	9.3	9.0	8.5	9.2	8.9	8.4	9.1	8.9	8.4
	22	10.1	9.8	9.3	10.0	9.8	9.3	9.9	9.7	9.2	9.9	9.6	9.1	9.8	9.6	9.1	9.8	9.5	9.0	9.7	9.4	8.9	9.6	9.4	8.9
	23	10.6	10.3	9.8	10.5	10.3	9.8	10.4	10.2	9.7	10.4	10.1	9.6	10.3	10.1	9.6	10.3	10.0	9.5	10.2	9.9	9.4	10.1	9.9	9.4
	24	11.1	10.8	10.3	11.0	10.8	10.3	10.9	10.7	10.2	10.9	10.6	10.1	10.8	10.6	10.1	10.8	10.5	10.0	10.7	10.4	9.9	10.6	10.4	9.9
	25	11.6	11.3	10.8	11.5	11.3	10.8	11.4	11.2	10.7	11.4	11.1	10.6	11.3	11.1	10.6	11.3	11.0	10.5	11.2	10.9	10.4	11.1	10.9	10.4
	26	12.1	11.8	11.3	12.0	11.8	11.3	11.9	11.7	11.2	11.9	11.6	11.1	11.8	11.6	11.1	11.8	11.5	11.0	11.7	11.4	10.9	11.6	11.4	10.9
	27	12.6	12.3	11.8	12.5	12.3	11.8	12.4	12.2	11.7	12.4	12.1	11.6	12.3	12.1	11.6	12.3	12.0	11.5	12.2	11.9	11.4	12.1	11.9	11.4
	28	13.1	12.8	12.3	13.0	12.8	12.3	12.9	12.7	12.2	12.9	12.6	12.1	12.8	12.6	12.1	12.8	12.5	12.0	12.7	12.4	11.9	12.6	12.4	11.9
	29	13.6	13.3	12.8	13.5	13.3	12.8	13.4	13.2	12.7	13.4	13.1	12.6	13.3	13.1	12.6	13.3	13.0	12.5	13.2	12.9	12.4	13.1	12.9	12.4
	30	14.1	13.8	13.3	14.0	13.8	13.3	13.9	13.7	13.2	13.9	13.6	13.1	13.8	13.6	13.1	13.8	13.5	13.0	13.7	13.4	12.9	13.6	13.4	12.9
	31	14.6	14.3	13.8	14.5	14.3	13.8	14.4	14.2	13.7	14.4	14.1	13.6	14.3	14.1	13.6	14.3	14.0	13.5	14.2	13.9	13.4	14.1	13.9	13.4
	32	15.1	14.8	14.3	15.0	14.8	14.3	14.9	14.7	14.2	14.9	14.6	14.1	14.8	14.6	14.1	14.8	14.5	14.0	14.7	14.4	13.9	14.6	14.4	13.9
	33	15.6	15.3	14.8	15.5	15.3	14.8	15.4	15.2	14.7	15.4	15.1	14.6	15.3	15.1	14.6	15.3	15.0	14.5	15.2	14.9	14.4	15.1	14.9	14.4
	34	16.1	15.8	15.3	16.0	15.8	15.3	15.9	15.7	15.2	15.9	15.6	15.1	15.8	15.6	15.1	15.8	15.5	15.0	15.7	15.4	14.9	15.6	15.4	14.9
	35	16.6	16.3	15.8	16.5	16.3	15.8	16.4	16.2	15.7	16.4	16.1	15.6	16.3	16.1	15.6	16.3	16.0	15.5	16.2	15.9	15.4	16.1	15.9	15.4
	36	17.1	16.8	16.3	17.0	16.8	16.3	16.9	16.7	16.2	16.9	16.6	16.1	16.8	16.6	16.1	16.8	16.5	16.0	16.7	16.4	15.9	16.6	16.4	15.9
	37	17.6	17.3	16.8	17.5	17.3	16.8	17.4	17.2	16.7	17.4	17.1	16.6	17.3	17.1	16.6	17.3	17.0	16.5	17.2	16.9	16.4	17.1	16.9	16.4
	38	18.1	17.8	17.3	18.0	17.8	17.3	17.9	17.7	17.2	17.9	17.6	17.1	17.8	17.6	17.1	17.8	17.5	17.0	17.7	17.4	16.9	17.6	17.4	16.9
	39	18.6	18.3	17.8	18.5	18.3	17.8	18.4	18.2	17.7	18.4	18.1	17.6	18.3	18.1	17.6	18.3	18.0	17.5	18.2	17.9	17.4	18.1	17.9	17.4
	40	19.1	18.8	18.3	19.0	18.8	18.3	18.9	18.7	18.2	18.9	18.6	18.1	18.8	18.6	18.1	18.8	18.5	18.0	18.7	18.4	17.9	18.6	18.4	17.9
	41	19.6	19.3	18.8	19.5	19.3	18.8	19.4	19.2	18.7	19.4	19.1	18.6	19.3	19.1	18.6	19.3	19.0	18.5	19.2	18.9	18.4	19.1	18.9	18.4
	42	20.1	19.8	19.3	20.0	19.8	19.3	19.9	19.7	19.2	19.9	19.6	19.1	19.8	19.6	19.1	19.8	19.5	19.0	19.7	19.4	18.9	19.6	19.4	18.9
	43	20.6	20.3	19.8	20.5	20.3	19.8	20.4	20.2	19.7	20.4	20.1	19.6	20.3	20.1	19.6	20.3	20.0	19.5	20.2	19.9	19.4	20.1	19.9	19.4
	44	21.1	20.8	20.3	21.0	20.8	20.3	20.9	20.7	20.2	20.9	20.6	20.1	20.8	20.6	20.1	20.8	20.5	20.0	20.7	20.4	19.9	20.6	20.4	19.9
	45	21.6	21.3	20.8	21.5	21.3	20.8	21.4	21.2	20.7	21.4	21.1	20.6	21.3	21.1	20.6	21.3	21.0	20.5	21.2	20.9	20.4	21.1	20.9	20.4
	46	22.1	21.8	21.3	22.0	21.8	21.3	21.9	21.7	21.2	21.9	21.6	21.1	21.8	21.6	21.1	21.8	21.5	21.0	21.7	21.4	20.9	21.6	21.4	20.9
	47	22.6	22.3	21.8	22.5	22.3	21.8	22.4	22.2	21.7	22.4	22.1	21.6	22.3	22.1	21.6	22.3	22.0	21.5	22.2	21.9	21.4	22.1	21.9	21.4

The Following Table Can be used to Determine the Maximum Spacing between ISS-Shear Studs:

Europe and Middle East

Flexural Bar Designation		10,0			12,0			14,0			16,0			20,0			25,0			28,0			32,0			40,0		
Clear Concrete Cover (mm)		20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75	20	30	75
Slab Thickness (mm)	120	45	40	N.A.	44	39	N.A.	43	38	N.A.	42	37	N.A.	40	35	N.A.	38	33	N.A.	36	31	N.A.	34	29	N.A.	30	25	N.A.
	150	60	55	N.A.	59	54	N.A.	58	53	N.A.	57	52	N.A.	55	50	N.A.	53	48	N.A.	51	46	N.A.	49	44	N.A.	45	40	N.A.
	180	75	70	48	74	69	N.A.	73	68	N.A.	72	67	N.A.	70	65	N.A.	68	63	N.A.	66	61	N.A.	64	59	N.A.	60	55	N.A.
	200	85	80	58	84	79	57	83	78	56	82	77	55	80	75	53	78	73	50	76	71	49	74	69	47	70	65	43
	225	98	93	70	97	92	69	96	91	68	95	90	67	93	88	65	90	85	63	89	84	61	87	82	59	83	78	55
	250	110	105	83	109	104	82	108	103	81	107	102	80	105	100	78	103	98	75	101	96	74	99	94	72	95	90	68
	275	123	118	95	122	117	94	121	116	93	120	115	92	118	113	90	115	110	88	114	109	86	112	107	84	108	103	80
	300	135	130	108	134	129	107	133	128	106	132	127	105	130	125	103	128	123	100	126	121	99	124	119	97	120	115	93
	325	148	143	120	147	142	119	146	141	118	145	140	117	143	138	115	140	135	113	139	134	111	137	132	109	133	128	105
	350	160	155	133	159	154	132	158	153	131	157	152	130	155	150	128	153	148	125	151	146	124	149	144	122	145	140	118
	375	173	168	145	172	167	144	171	166	143	170	165	142	168	163	140	165	160	138	164	159	136	162	157	134	158	153	130
	400	185	180	158	184	179	157	183	178	156	182	177	155	180	175	153	178	173	150	176	171	149	174	169	147	170	165	143
	425	198	193	170	197	192	169	196	191	168	195	190	167	193	188	165	190	185	163	189	184	161	187	182	159	183	178	155
	450	210	205	183	209	204	182	208	203	181	207	202	180	205	200	178	203	198	175	201	196	174	199	194	172	195	190	168
	475	223	218	195	222	217	194	221	216	193	220	215	192	218	213	190	215	210	188	214	209	186	212	207	184	208	203	180
	500	235	230	208	234	229	207	233	228	206	232	227	205	230	225	203	228	223	200	226	221	199	224	219	197	220	215	193
	525	248	243	220	247	242	219	246	241	218	245	240	217	243	238	215	240	235	213	239	234	211	237	232	209	233	228	205
	550	260	255	233	259	254	232	258	253	231	257	252	230	255	250	228	253	248	225	251	246	224	249	244	222	245	240	218
	575	273	268	245	272	267	244	271	266	243	270	265	242	268	263	240	265	260	238	264	259	236	262	257	234	258	253	230
	600	285	280	258	284	279	257	283	278	256	282	277	255	280	275	253	278	273	250	276	271	249	274	269	247	270	265	243
	625	298	293	270	297	292	269	296	291	268	295	290	267	293	288	265	290	285	263	289	284	261	287	282	259	283	278	255
	650	310	305	283	309	304	282	308	303	281	307	302	280	305	300	278	303	298	275	301	296	274	299	294	272	295	290	268
	675	323	318	295	322	317	294	321	316	293	320	315	292	318	313	290	315	310	288	314	309	286	312	307	284	308	303	280
	700	335	330	308	334	329	307	333	328	306	332	327	305	330	325	303	328	323	300	326	321	299	324	319	297	320	315	293
	750	360	355	333	359	354	332	358	353	331	357	352	330	355	350	328	353	348	325	351	346	324	349	344	322	345	340	318
	800	385	380	358	384	379	357	383	378	356	382	377	355	380	375	353	378	373	350	376	371	349	374	369	347	370	365	343
	850	410	405	383	409	404	382	408	403	381	407	402	380	405	400	378	403	398	375	401	396	374	399	394	372	395	390	368
	900	435	430	408	434	429	407	433	428	406	432	427	405	430	425	403	428	423	400	426	421	399	424	419	397	420	415	393
	950	460	455	433	459	454	432	458	453	431	457	452	430	455	450	428	453	448	425	451	446	424	449	444	422	445	440	418
	1000	485	480	458	484	479	457	483	478	456	482	477	455	480	475	453	478	473	450	476	471	449	474	469	447	470	465	443
	1050	510	505	483	509	504	482	508	503	481	507	502	480	505	500	478	503	498	475	501	496	474	499	494	472	495	490	468
	1100	535	530	508	534	529	507	533	528	506	532	527	505	530	525	503	528	523	500	526	521	499	524	519	497	520	515	493
	1150	560	555	533	559	554	532	558	553	531	557	552	530	555	550	528	553	548	525	551	546	524	549	544	522	545	540	518
	1200	585	580	558	584	579	557	583	578	556	582	577	555	580	575	553	578	573	550	576	571	549	574	569	547	570	565	543

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