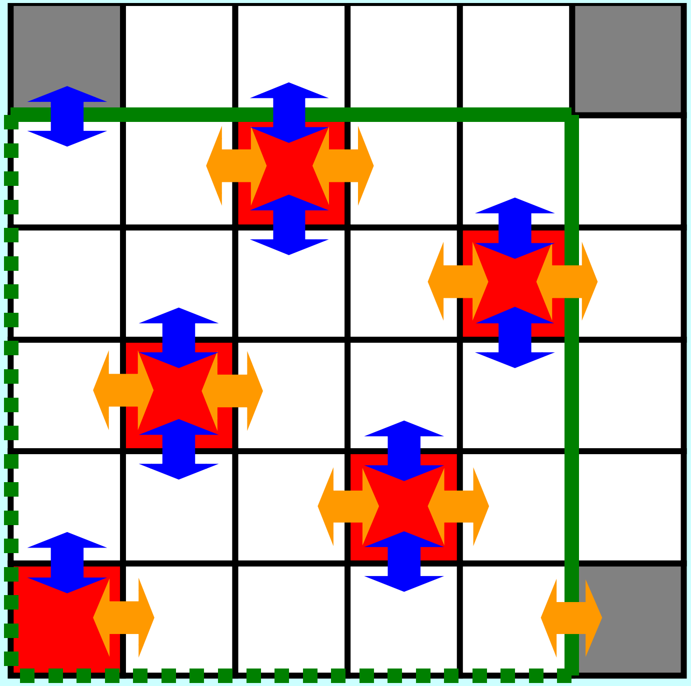
„DEFINITIONS, RELATIONS“



WOVEN FABRICS 1

Woven fabric – areal formation from 2 yarn systems (rarely more, e.g. three-axial fabrics), mutually interlaced

Yarn systems – 1) WARP – "longitudinal" direction, (direction of fabric production), subscript 'o'

– 1) WEFT – "transversal" direction, (perpendicular to the direction of production), subscript 'u'

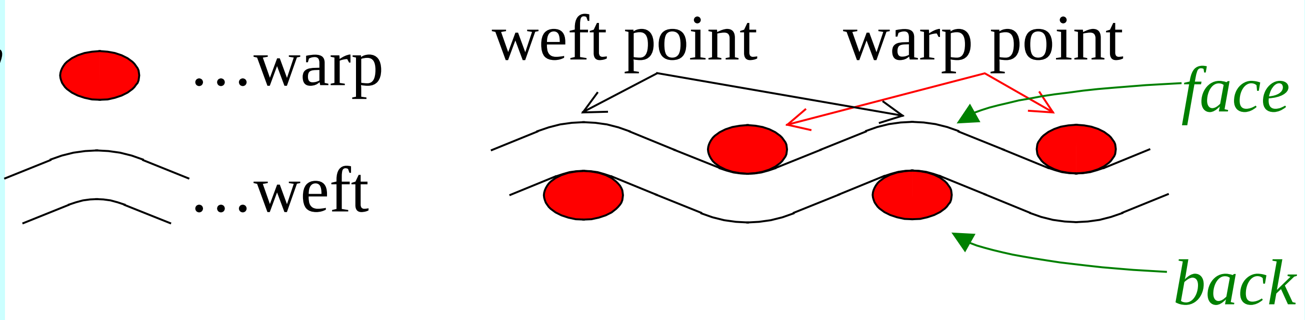
Weave of fabric

Face - "upper" side of fabric (usually outer side of dress)

Back – "lower" side of fabric (back side)

Binding point – place of crossing of warp and weft yarns

Scheme: Cross-section of fabric across to warp yarns

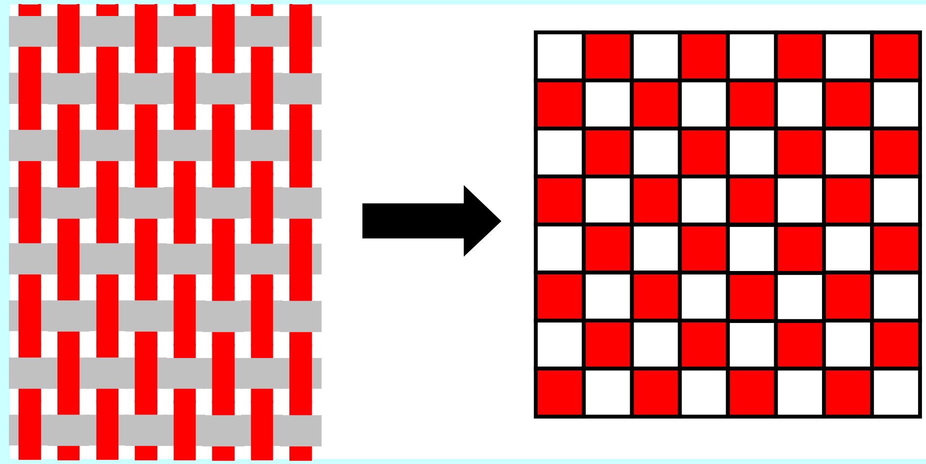


WOVEN FABRICS 1

Record of weave – on the pattern paper

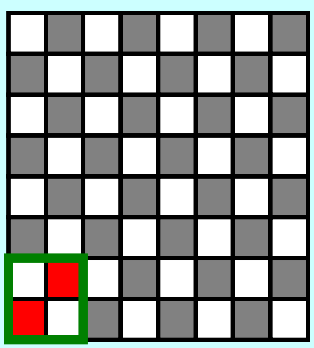
... warp binding point - dark (red)

... weft binding point - white (non colo-red)

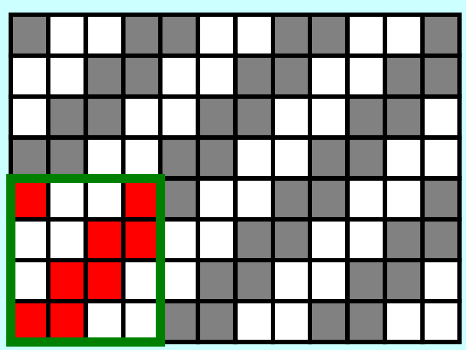


Ground waves – *examples:*

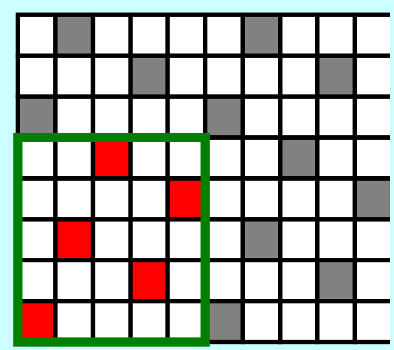
PLAIN WEAVE



TWILL WEAVE 2/2 Z



SATIN WEAVE 1/4 (3)



...**pattern repeat**

Repetitious structural unit of fabrics

WOVEN FABRICS 1

Note: We shall relate major part of following ideas to the corresponding pattern repeat

Number of warp yarns in pattern... n_o

Number of weft yarns in pattern... n_u

Number of binding points in pattern... $v = n_o n_u$

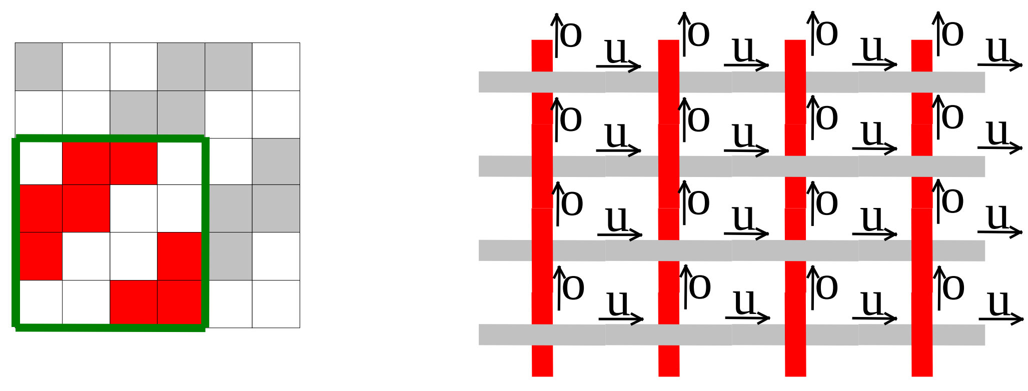
Yarn segment – part of yarn, connect 2 neighboring binding points. (yarn segments comes from each binding point – just one of warp and just one of weft; see figure.)

Number of warp segments ($\uparrow$o)... v

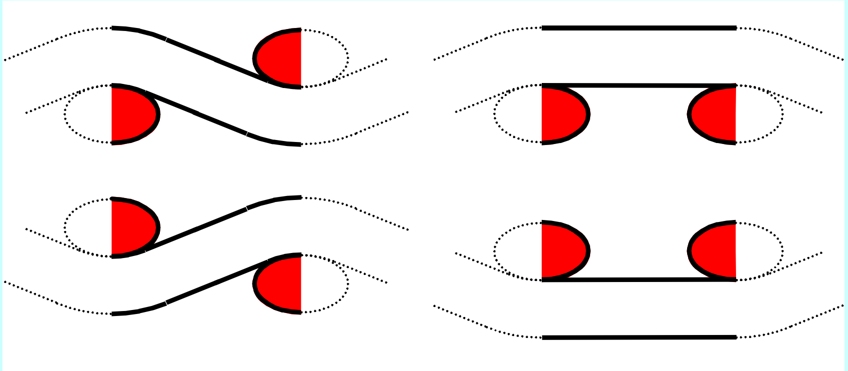
Number of warp segments ($\underrightarrow{u}$)... v

Number of all segments in the pattern

$$2v = 2 n_o n_u$$



Two types of segments exists: CROSSED NON-CROSSED



Crossed segment – connects warp and weft binding points

Non-crossed segment – connects two identical binding points (warp-warp or weft-weft)

Note: a) Minimum 2 crossed segments must be on each yarn in the pattern. (Repeat repetitious structural unit.)

b) Minimum 2 yarns in each system (warp, weft) must be in the repeat.

So minimum number of crossed segments per one system in repeat must be 2x2=4.

Maximum number of crossed segments per one system (warp, weft) in pattern is represented by all segments in the pattern, i.e. for each system by the number $v = n_o n_u$. The number of crossed segments of warp z_o and/or weft z_u lies in the intervals $z_o \in \langle 4, v \rangle$, $z_u \in \langle 4, v \rangle$. The total number of crossed segments z in the pattern lie in the interval $z = (z_o + z_u) \in \langle 8, 2v \rangle$

Crossing factors – are the quotients of crossed segments in relation to number of all segments.

Warp crossing factor... $\kappa_o = z_o / v \leq 1$

weft crossing factor... $\kappa_u = z_u / v \leq 1$

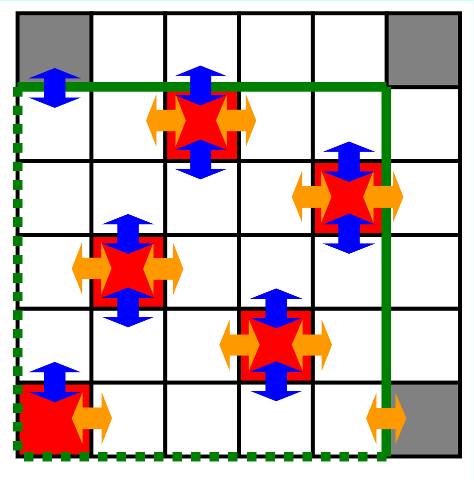
Crossing factor of fabric...

$$\kappa = \underbrace{z}_{=z_o + z_u} \Big/ \underbrace{2v}_{\text{No. of all segments}} = \frac{\overbrace{z_o / v}^{=\kappa_o} + \overbrace{z_u / v}^{=\kappa_u}}{2}, \quad \kappa = \frac{\kappa_o + \kappa_u}{2}$$

WOVEN FABRICS 1

Note: Only the plain weave has the highest value $\kappa_o = \kappa_u = \kappa = 1$ of crossing factor. Other weaves have always a smaller values.

Example: FIVE-END SATIN



Number of warp and weft yarns in the pattern... $n_o = 5,\ n_u = 5$

No. of binding points in the pattern...

$$v = n_o n_u = 25$$

No. of crossed segments on warp yarns (5 yarns, 2 crossed segments per yarn)... $z_o = 10$

No. of crossed segments on weft yarns (5 yarns, 2 crossed segments per yarn)... $z_u = 10$

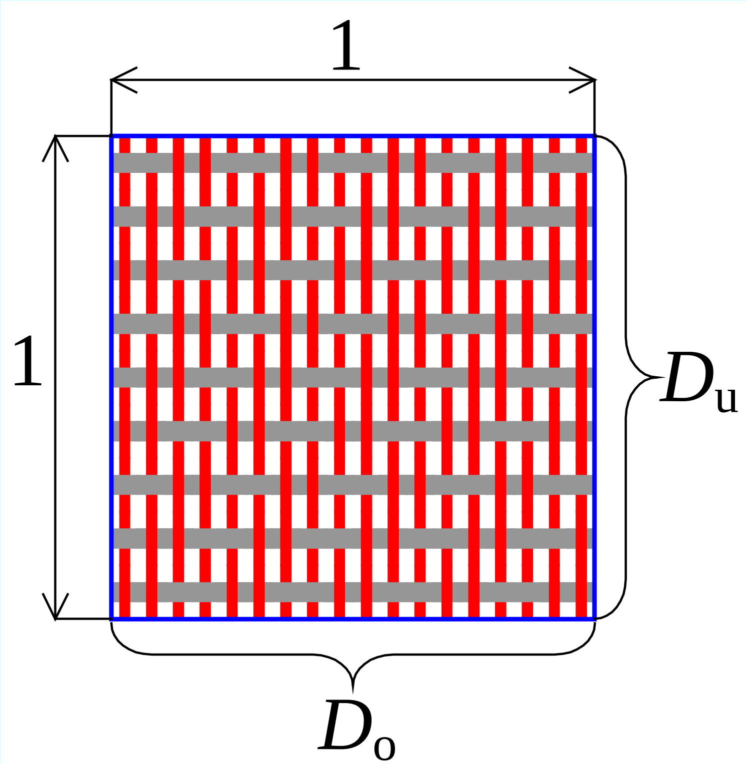
Warp crossing factor... $\kappa_o = z_o / v = 10/25 = 0,4$

Weft crossing factor... $\kappa_u = z_u / v = 10/25 = 0,4$

Crossing factor of fabric... $\kappa = (\kappa_o + \kappa_u)/2 = 0,4$

Fabric density

Let us think about a square unit 1x1 (□) of woven fabric – see figure



1. SETTS

We characterize warp density (red) by No. of warp yarns per length unit – so called

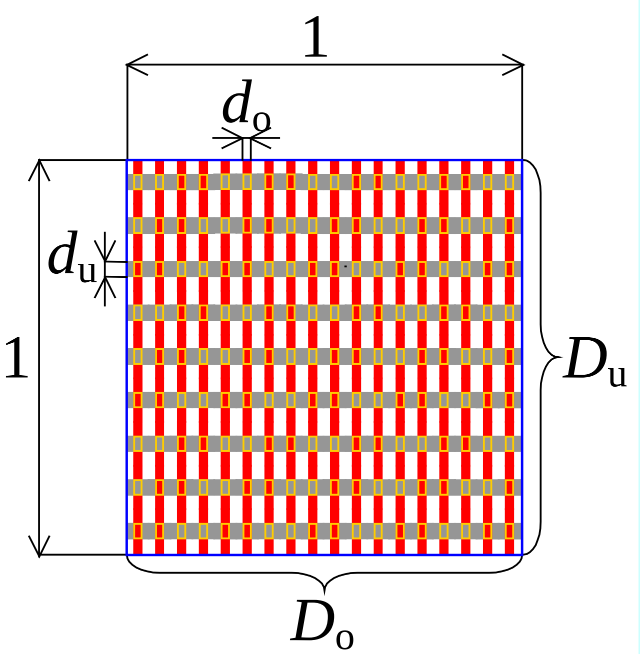
warp sett... D_o

Similarly we characterize also weft density (gray) by

weft sett... D_u

Note: The dimensions of setts can be m^{-1}, cm^{-1} , $inch^{-1}$ and so on. (E.g. 2000 m^{-1}, 18 cm^{-1}.)

2. AREAL COVERING (Cover factor)

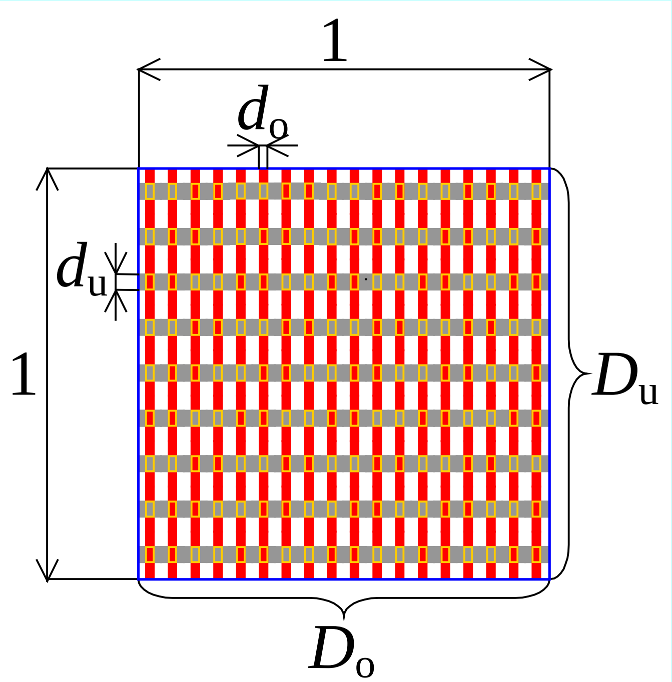


By the same values of setts the fabric created from "thick" yarns is more "filled" then a fabric from "thin" yarns ⇒ we must think about **diameter of the warp yarn**... d_o, **diameter of the weft yarn**... d_u

The square area (□) is 1x1. The covered area per one warp (red) yarn is $d_o \cdot 1$, number of such yarns is D_o. The covered area by all warp yarns is $D_o(d_o \cdot 1)$. The quotient of covered and total area is the quantity called as

covering by warp ... $Z_o = \overbrace{D_o(d_o \cdot 1)}^{\text{covered area}} \Big/ \overbrace{(1 \cdot 1)}^{\text{total area}}$, $\quad Z_o = D_o d_o$

Similarly we define **covering by weft**... $Z_u = D_u d_u$



The covering of fabric is an effect of warp and weft together,

~~$Z = Z_o + Z_u$~~ ? ... NO !

Yellow rectangles on the places of binding points are 2x covered (warp, weft) $\Rightarrow$ one times we must take these off from the sum of covered areas.

Number of (yellow) rectangles... $D_o D_u$

Area of one (yellow) rectangle ... $d_o d_u$

Total area of all (yellow) rectangles

$$D_o D_u \cdot d_o d_u = \underbrace{D_o d_o}_{=Z_o} \underbrace{D_u d_u}_{=Z_u} = Z_o Z_u$$

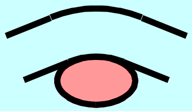
Covering of fabric... $Z = Z_o + Z_u - Z_o Z_u$

Notes: 1) We must use the same length unit for setts and yarn diameters (e.g. $D_{o[mm^{-1}]}, d_{o[mm]}, D_{u[mm^{-1}]}, d_{u[mm]}$) or rear-range corresponding relations, e.g.

$$Z_{o[1]} = D_{o[m^{-1}]} d_{o[mm]} / 1000, \quad Z_{u[1]} = D_{u[m^{-1}]} d_{u[mm]} / 1000$$

2) Quantities of covering are dimensionless, ≤ 1. They are also interpreted "in percentage" i.e. 100x higher; then it is valid for covering of fabric

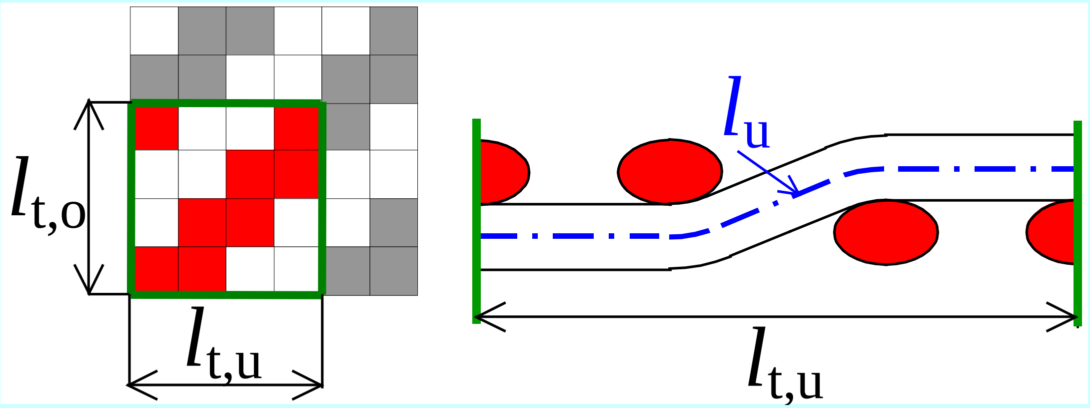
$$Z_{[\%]} = Z_{o[\%]} + Z_{u[\%]} - Z_{o[\%]} Z_{u[\%]} / 100$$

3) The yarn is flattened in the fabric (), but we usually use the beginning non-deformed ("free") diameter of the yarn. So we obtain an "effective covering".

Crimp and areal mass of fabrics

Dimesions of repeat
- in warp... $l_{t,o}$
- in weft... $l_{t,u}$

Length of yarn in repeat
- warp... l_o, $l_o > l_{t,o}$
- weft... l_u, $l_u > l_{t,u}$



Warp crimp

$$s_o = \frac{l_o - l_{t,o}}{l_{t,o}}$$

$$s_o l_{t,o} = l_o - l_{t,o}, \quad s_o l_{t,o} + l_{t,o} = l_o,$$

$$l_o = l_{t,o}(1 + s_o)$$

Weft crimp

$$s_u = \frac{l_u - l_{t,u}}{l_{t,u}}$$

$$s_u l_{t,u} = l_u - l_{t,u}, \quad s_u l_{t,u} + l_{t,u} = l_u,$$

$$l_u = l_{t,u}(1 + s_u)$$

Note: In practice crimp is used “in percentage”, i.e. in 100x higher values.

Crimp represents the strain (relative elongation) of yarn after its separation from fabric.

(If the warp crimp is e.g. s_o=0.05, i.e. 5%, then the yarn length 105 cm was in 1 meter of fabric.)

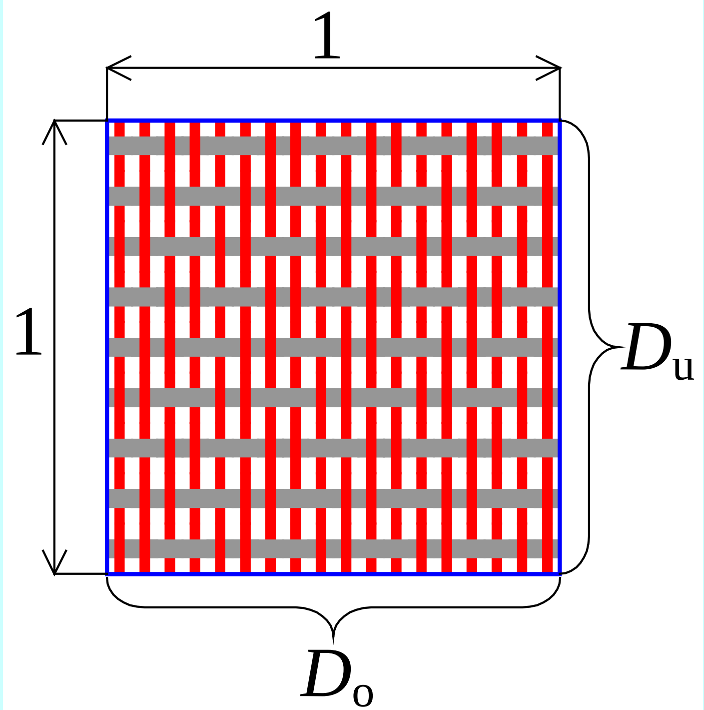
Notes: 1) Crimp values of warp and weft is possible to determine either empirically (from technological and/or laboratory experiences) or estimate them from a theoretical model of woven fabric.

2) Crimp is very important in practice for good estimation of areal mass (weight) of fabric, too. (Price of fiber material is the dominant part of total price of a fabric.)

WOVEN FABRICS 1

Areal mass expresses the mass of areal unit of fabric.

Areal mass of warp expresses the mass of warp yarns in areal unit (□) of fabric. Here is the length of one warp yarn



$$L_o = 1 + s_o$$

(It is valid $\overbrace{l_o}^{\text{Length } L_o \text{ of yarn in fabric, now}} = \overbrace{l_{t,o}}^{\text{Length of fabric equal to 1, now}} (1+s_o)$.)

Fineness (count) of warp yarn... T_o

Mass of warp yarn (from definition of T)... $g_o = T_o \overbrace{L_o}^{=1+s_o} = T_o(1+s_o)$

Areal mass of warp... $G_o = D_o \overbrace{g_o}^{=T_o(1+s_o)}$, $G_o = D_o T_o (1+s_o)$

Similarly we can derive
areal mass of weft... $$G_u = D_u T_u (1 + s_u)$$

Finally
areal mass of fabric... $$G = \overbrace{G_o}^{=D_o T_o (1+s_o)} + \overbrace{G_u}^{=D_u T_u (1+s_u)},$$

$$G = D_o T_o (1 + s_o) + D_u T_u (1 + s_u)$$

Note: Industry expresses these quantities usually in physical unit $[\mathrm{g\,m^{-2}}]$ (E.g. shirting can have areal mass of fabric $120\,\mathrm{g\,m^{-2}}$, lounge suit can have $300\,\mathrm{g\,m^{-2}}$.)